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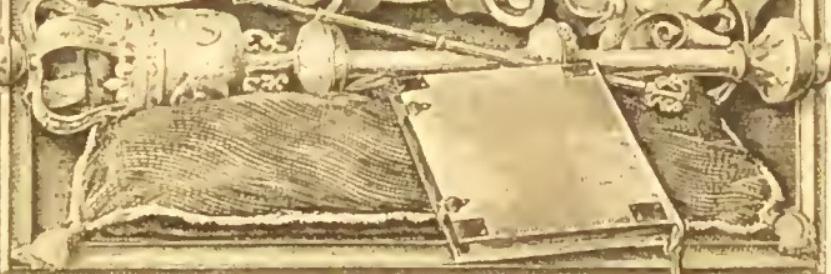
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# M. Baillie

A  
PRACTICAL ESSAY  
ON  
CHEMICAL RE-AGENTS  
OR  
**T E S T S.**

ILLUSTRATED BY A SERIES OF EXPERIMENTS,



BY FREDRICK ACCUM,  
OPERATIVE CHEMIST,

LECTURER ON PRACTICAL CHEMISTRY, ON MINERALOGY, AND ON  
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MEMBER OF THE ROYAL ACADEMY OF SCIENCES, AND OF THE  
ROYAL SOCIETY OF ARTS OF BERLIN, &c. &c.

LONDON:

PRINTED FOR J. CALLOW, MEDICAL BOOKSELLER,  
10, CROWN COURT, PRINCES STREET, SOHO.

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1816.

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Poppin's Court, Fleet Street.*

## P R E F A C E.

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No. 11, Compton Street, Soho.

*THE following pages are intended to exhibit a summary view of the general nature of chemical re-agents or tests, with the effects and phenomena which are produced by the action of these bodies—the particular uses to which they may be applied in the various pursuits of chemical science—and the art of applying them successfully.*

A

*To accomplish this object, I have in the first place stated the characteristic powers of each individual test, and have afterwards proceeded, to illustrate its attributes, and peculiar mode of action, by a series of experiments, sufficiently striking to interest the mind, and imprint its generalities on the memory.*

*In selecting the illustrative proofs, I have chosen such experiments only, as are easy to be performed, and the exhibition of which requires no other agents, than a mere collection of the chemical tests enumerated in the treatise, in addition to a few articles of*

*commerce, which may readily be procured.*

*I have given a list of all those substances for which there exist any appropriate tests, with direct references to the manner in which those substances may individually be detected.*

*And I have also pointed out the precautions necessary to be observed, to guard against deceitful appearances that may occur under certain circumstances, and without which precautions, chemical tests are of little utility.*

*In fact, I have not only endeavoured*

*to render this treatise useful to the young chemist, but it has also been my aim to give it such a popular form, as to place the subject on which it treats within the reach, even of those, who are unacquainted with the principles of chemical science.*

*The student in particular, will it is presumed, readily comprehend the signals by which the chemist steers ; he will find no difficulty in applying chemical re-agents to original investigations, whilst at the same time, he will become enabled to perform a series of amusing and instructive experiments, well calculated to illustrate the chemical*

*affinities of different bodies, and the most important changes of which they are susceptible in their reciprocal action—he will thus become acquainted with the laws that govern the composition and decomposition of bodies, and with the practical processes by which the constituent parts of compound bodies are discovered.*

FREDRICK ACCUM

LONDON, 1816.



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## DEFINITION AND GENERAL NATURE OF CHEMICAL Re-agents or Tests.

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GENERAL nature of Chemical Tests—purposes for which they are employed—phenomena arising from the action of these bodies—upon what founded—manner in which they indicate the absence or presence of the substances, for the detection of which they are employed—precautions to avoid fallacious results—services they render to the practice of chemistry—were first used by Boyle in 1663, who was acquainted with the tests for detecting acids, alcalies, copper, silver, mercury, &c.—Ducloss, in 1666, employed re-agents in the chemical examination of mineral waters—further pursuit of the subject by modern philosophers.

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FOR WHICH THERE EXIST ANY APPROPRIATE

## TESTS,

WITH REFERENCES TO THE MANNER IN WHICH  
THEY ARE DETECTED.

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### ACIDS IN GENERAL,

**TESTS**—Tincture of Litmus, page 8,  
19—Tincture of Red Cabbage,  
28—the same Tincture rendered green by an aleali—  
—Turmeric paper rendered brown by an aleali, 39.

### ACID BORACIC,

**TEST**—Super-Aacetate of Lead, 114.

### CARBONIC,

**TESTS**—Tincture of Litmus, 8, 19—  
Sulphuric acid, 40. 43—Lime water, 97—Barytic water, 191  
—concentration by boiling, 11.

### CHROMIC,

**TEST**—Nitrate of Silver, 80.

**ACID FLUORIC,**

*TEST*—Corrodes glass, 42, 46.

**— GALLIC,**

*TESTS*—Sulphate of iron 130—and  
Salts of Iron in general.

**— MURIATIC,**

*TESTS*—Nitrate of Silver, 79—Acetate  
of Silver, 92—Sulphate of Sil-  
ver, 94—Sub-Nitrate of Mer-  
cury, 75—Super-acetate of  
Lead, 112—sulphuric acid, 40

**— OXALIC,**

*TESTS*—Muriate of Lime, 138—Solu-  
tions of lime in general.

**— PHOSPHORIC,**

*TESTS*—Sub-Nitrate of Mercury, 75,  
77—Super-Acetate of Lead,  
112.

**— SULPHURIC,**

*TESTS*—Barytic water, 191—Muriate  
of Barytes, 196—Acetate of

Barytes, 209—Nitrate of Barytes, 203—Super-Acetate of Lead, 112—Sub-Nitrate of Mercury, 75.

### ACID URIC,

*TEST*—Nitric acid, 50

### ALBUMEN,

*TESTS*—Oxy-Muriate of Mercury, 69  
Muriate of gold, 134—Sub-Muriate of Tin, 157.

### ALCALIES IN GENERAL,

*TESTS*—Tincture of Cabbage, 28—Tincture of Turmeric, 34—Turmeric paper, 34—Litmus paper reddened by an acid, 23—Oxy-Muriate of Mercury, 69—Tincture of Brazil wood, 30—Brazil wood paper, 30.

### ALUMINE,

*TEST*—Nitrate of Cobalt, 109, 111.

### AMMONIA,

*TESTS*—Muriatic acid, 55—Oxy-Muriate of Mercury, 71—Sub-Nitrate of Mercury, 75.

**ANTIMONY,**

**TESTS**—Liquid Sulphuretted hydrogen,  
142.

**ARSENIC,**

**TESTS**—Sub-Nitrate of Silver, 80—  
Liquid Sulphuretted hydrogen,  
142 -Sulphate of Copper, 135  
—Sulphate of Copper and  
Ammonia, 154.

**AZOTE COMBINED,**

**TEST**—Nitric acid 49.

**BARYTES,**

**TESTS**—Sulphuric acid, 40 — Sul-  
phates in general.

**BORACIC ACID,**

**TEST**—Super-acetate of Lead, 114.

**CARBONATES IN GENERAL,**

**TEST**—Sulphuric acid, 40.

**CARBONATED ALCALIES,**

**TESTS**—Litmus paper reddened with an acid, 22—Tincture of Brazil wood, 30—Tincture of Cabbage, 29—Muricate of Lime, 138.

**CARBONATED EARTHS, WITH EXCESS OF CARBONIC ACID,**

**TESTS**—Precipitation by boiling and evaporation, either wholly or partially, 11—Tincture of Brazil wood, 30—Litmus paper reddened by an acid, 22.

**COBALT,**

**TEST**—Forms by fusion a blue glass with borax, 240.

**COPPER,**

**TESTS**—Liquid Ammonia, 160—Carbonate of Ammonia, 210—polished Zinc, 220—Iron, 227.

**CORROSIVE SUBLIMATE,**

**TEST**—Zinc and Gold arranged as a Galvanic circle, 225.—

**FLUATS,**

**TEST**—Sulphuric acid, 42.

**GELATINE ANIMAL,**

**TEST**—Tan, 107.

**GLUTEN,**

**TEST**—Acetic acid, 63.

**GOLD,**

**TESTS**—Green Sulphate of iron, 130—Sub-Muriate of Tin, 156—Tin, 227.

**HYDRO-SULPHURETS IN GENERAL,**

**TEST**—See Sulphuretted Hydrogen Gas.

**IODINE,**

**TEST**—Starch, 205.

**IRON IN GENERAL,**

**TESTS**—Tincture of Galls, 147—Prussiate of Potash, 175—Succinate of Ammonia, 204.

**IRON DISSOLVED IN CARBONIC ACID,**

**TESTS**—Precipitation, by boiling and evaporation, 151, 178.

**LEAD,**

**TESTS**—Muriatic acid, 54—Liquid sulphurated hydrogen, 142—Sulphate of soda, or of potash, 208—Zinc, 220.

**LIME IN GENERAL,**

**TESTS**—Liquid carbonic acid — Air from the lungs, 100—Oxalic acid, 64—Oxalate of ammonia, 170.

**LIME DISSOLVED BY CARBONIC ACID,**

**TESTS**—Tincture of litmus, 8—Litmus paper reddened by vinegar, 22—Tincture of Brazil wood, 30—Oxalic acid, 64—Oxalate of ammonia, 170—Precipitation on boiling, 11.

MAGNESIA,

**TESTS**—Phosphate of soda, 95—Liquid ammonia, 162.

MAGNESIA DISSOLVED BY CARBONIC ACID,

**TEST**—Precipitation partially on boiling liquid ammonia, 162.

MANGANESE,

**TESTS**—Muriatic acid, 55—yields a violet coloured glass when fused with borax, 240.

MERCURY IN GENERAL,

**TEST**—Galvanic circle of Gold and Zinc, 225.

MURIATES IN GENERAL,

**TESTS**—Nitrate of Silver, 79—Acetate of Silver, 92—Sulphate of Silver, 94—Sub-Nitrate of Mercury, 75—Super-Acetate of Lead, 112.

## MUCOUS,

*TEST*—Sub-Acetate of Lead, 121.

## NITRATES IN GENERAL,

*TEST*—Sulphuric acid, 42.

## NITROGEN,

*TEST*—Nitric acid, 49.

## NICKEL,

*TEST*—Ammonia, and Zinc, 161.

## OXYGEN GASS IN MINERAL WATERS,

*TEST*—Green Sulphate of Iron, 131.

## OXY-MURIATE OF MERCURY,

*TEST*—Lime water, 98—Zinc with Gold, 225.

## PLATINA,

*TEST*—Muriate of Ammonia, 65—Sub-Muriate of Tin, 156.

## PALLADIUM,

*TEST*—Prussiate of Mercury, 188.

**POTASH AND ITS SALINE COMPOUNDS,**

**TEST**—Muriate of Platina, 128—  
Tartareous acid, 58—Acetate  
of Barytes, 201, with the  
sulphate,—and acetate of Sil-  
ver, 92, with the Muriates.

**SILVER,**

**TEST**—Muriatic acid, 54—all the  
muriates,

**STARCH,**

**TEST**—Iodine, 206—Nitric acid, 48.

**STEEL,**

**TEST**—Nitric acid, 50.

**SULPHATES IN GENERAL,**

**TEST**—Barytic water, 191—Muriate  
of Barytes, 196—Nitrate Ba-  
rytes, 203—Acetate Barytes,  
200—Super-Acetate of Lead,  
112—Alcohol, 211.

LIST OF SUBSTANCES.                           xli

SULPHURETS AND SULPHURETTED  
HYDROGEN GASS,

*TEST*—Silver leaf, 231—Quicksilver,  
231—Nitrate of Silver, 80—  
Super-acetate of Lead, 114—  
Arsenious acid, 133—Fœted  
odour—Tincture of Litmus, 8.

TAN,

*TEST*—Animal Jelly, 107.

TELLURIUM,

*TEST*—Tincture of Galls, 150.

TIN,

*TEST*—Sub-Muriate of Gold, 134—  
Muriate of Platina, 128.

ZINC,

*TEST*—Liquid Ammonia, 162.

## Advertisement.

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The Public is respectfully informed that portable Chests, containing Select Collections of all the Chemical Tests and Apparatus, necessary for performing the Experiments described in this Treatise, may be had as a Companion to this Work

FREDRICK ACCUM.

No. 11, Compton Street, Soho.

A

## PRACTICAL ESSAY,

&c. &c.

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### DEFINITION AND GENERAL NATURE OF CHEMICAL TESTS.

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CHEMICAL TESTS, or Re-agents, are called those substances, which when applied to other bodies, the nature, or composition of which are unknown, *quickly* act upon them, and produce such changes as are sufficiently striking to the senses, and from which the quality or nature of the unknown body may be inferred.

B

As the chemical affinities of bodies towards each other are various, the constituent parts of compound bodies may be easily disengaged by other substances; and it is upon this consideration that the action of all the Re-agents or tests employed by chemistry in its analysis is founded. For the great object of acquiring a knowledge of the chemical nature of bodies consists in separating their component parts; but this is seldom practical without, at the same time, uniting them to another body, and it is this that leads to the object in view, namely, the knowledge of the composition of the substance under examination. It is thus that Re-agents frequently act. The test combines with some principle of the body with which it is brought into contact; and a compound arises, whose characters at once indicate to us, the nature of the principle which has entered into combination, because the combinations of the principal Re-agents with various bases are well known. Sometimes the Re-agent displaces from the body under examination, certain constituent

parts or principles only; which in that state may be examined more accurately, and with less trouble, because insulated and disengaged from their combinations.

It likewise frequently happens, that the Re-agent made use of, is itself decomposed, which circumstance renders the phenomena and the products more complicated; but we are enabled from the characters of these products, and their actions upon other bodies, to form a judgment of the component parts of the body analysed. This last fact was little attended to by the ancient chemists; and this is one of the principal defects of their labours; because they referred many of those phenomena, to the bodies which they submitted to their analysis, which in reality arose only from the decomposition of the Re-agents employed in their operations.

Most of the tests employed in the processes of chemistry, indicate the component parts of bodies, by occasioning either a precipitate, a sensible cloudiness, a change of colour, an effervescence, or such other altera-

tions of properties as experience has proved denote the presence or absence of certain bodies.

It may be readily conceived, that a vast variety of substances, provided their chemical actions be well established, may serve as Re-agents or tests, and that even no compound is useless to a skilful chemist in his analytical operations. But by long search and experience we have learnt to make a choice of some particular bodies only, the effects of which are rapid, and the application of which requires no skill, and to these bodies the name of Re-agents or tests, has been given by mutual consent.

There are, however, two circumstances which render it necessary that the substances used as tests should be applied with care and circumspection; one is, that the same body used as a Re-agent, frequently produces a similar apparent effect, on two, three, or more different matters contained in the compound to which it is presented; the other, that one Re-agent may produce several of

those effects with one and the same substance. Both these inconveniences may be remedied, by employing and comparing the effects of several of the Re-agents, and by assisting their action by other agencies calculated to render the results unequivocal. This mode of proceeding, the only one, that can render the use of chemical tests much more certain and advantageous, therefore supposes that we do not precisely fix certain specific tests, for certain specific substances under all circumstances, and that we take the facts we are in search of, from the united effects, produced by the summary action of several tests, applied under different circumstances, as will be pointed out in the sequel.

The application and importance of the substances made use of, as Re-agents, was first pointed out by the illustrious Boyle. It had long before been known indeed, that the blue colour of the violet flower, was reddened by sulphuric acid, lemon juice, and vinegar; but this philosopher proved that the reddening property belonged to all acids, and

that it was a leading property which characterises this class of bodies. He was also the first who observed that alkalies render the blue colour of vegetables, green, which he instances in the juice of the flowers of the blue-bell, and the blue Iris. He mentions the effect of volatile alkali or ammonia, in producing a blue transparent fluid, with solutions of copper, and he relates that the colour of rose leaves is destroyed by the fumes of burning sulphur or sulphurous acid; but heightened by sulphuric acid. That water tinged red with Brazil wood, becomes yellow by acids, and that alkalies restore the original colour of the tincture: that silver is precipitated from its solutions by common salt and sulphuric acid, and that the precipitate is blackened on exposure to the rays of the sun, or the mere light of day. That sulphate of mercury acquires a yellow colour by the affusion of boiling water; that quicksilver dissolved in nitric acid, occasions an orange coloured precipitate with fixed alkalies, and that metals and metallic solutions

become blackened by sulphurets of all kinds. He also points out the effects of lime water, and acetate of lead, as tests for various bodies, and he describes the compounds which they produce.

Soon afterwards, namely, in the year 1665, M. Duclos employed tincture of galls, sulphate of iron, and tincture of litmus, as Re-agents in the analysis of some mineral waters of France ; and made some useful critical remarks on the golden colour given to silver by sulphureous waters and on other Re-agents which had begun to be employed, and recommended by Boyle.

In 1685 Boyle again gave some new instructions for using the tests which he had pointed out in the year 1663, and he strongly recommended his *fuming liquor* (hydro-sulphuret of ammonia,) as a test useful in the analysis of mineral waters ; as well as solutions of sea salt, sal ammoniae, nitric acid, muriatic acid, and ammonia, which he extolled as deserving the notice of the chemist. And from that period chemical re-agents were employed,

but the conclusions drawn from their effects were long inaccurate, and erroneous.

The list of chemical Re-agents, however, has been greatly augmented by the labours of modern chemists, and we are particularly indebted to Bergman, Scheele, Kirwan, and Westrumb, for the knowledge of the particular actions of numerous Re-agents, and the modes of applying them with success in the multifarious researches of chemical science.

The following are the most essential tests now made use of in chemistry.

## LIST OF CHEMICAL TESTS.

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### I. TINCTURE OF LITMUS.

This test is employed for detecting the presence of uncombined acids, by which it becomes changed to red; its natural colour being a dark blue, inclining to purple. If the redness vanishes by suffering the fluid to stand exposed to the open air, or when con-

centrated by boiling, and reappears by a fresh addition of a portion of the fluid, we then are sure that the acid is either carbonic acid gas, or sulphuretted hydrogen gas; a substance which, in this, as well as in every other case performs the function of an acid. If the redness is produced by carbonic acid gas, the fluid becomes *immediately* turbid by the admixture of Barytic water, and a precipitate falls down which is soluble with effervescence in pure dilute muriatic or nitric acid.

But if the redness is owing to sulphuretted hydrogen gas, no precipitate takes place, and this forms a decisive criterion to distinguish the action of carbonic acid gas upon litmus, from that of sulphuretted hydrogen gas. Besides, a fluid containing sulphuretted hydrogen gas, even when the portion of the gas is very small, always exhales a strong *foetid* odour, resembling that of putrid eggs. A drop of nitrate of silver, super-acetate of lead, or muriate of bismuth, render it instantly *black*, but no such effect is produced with carbonic acid gas.

10. A PRACTICAL ESSAY

If the reddened tincture of litmus does not become blue again, after it has suffered to stand exposed to the free contact of air, or better, when it has been concentrated by boiling to about one half of its original bulk, we are then sure that the redness is occasioned by a fixed acid, the nature of which may be ascertained by other tests; as will be pointed out hereafter.

EXPERIMENT I.

Into a test tube\* half filled with distilled water, let fall a drop or two of tincture of litmus; the blue colour of the tincture will not be altered.

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\* *Test tubes* are called glass tubes, three or four inches long, and from  $\frac{1}{2}$  inch to  $\frac{3}{4}$  of an inch in diameter, closed and rounded off at one end, and open at the other, with a rim a little turned over, to pour liquids out from them conveniently. They are useful for observing the changes of colour, and the phenomena produced by the action of chemical tests, as well as for dissolving solids, precipitating solutions, &c. A series

## EXPERIMENT II.

Add to a wine-glass full of distilled water impregnated with carbonic acid gas, (for the mode of preparing this water, see index, or take common seltzer water of commerce,) a small quantity of tincture of litmus, its colour will become changed to red. Put the water into one of the evaporating basins contained in the chest, place the basin on the ring over the lamp-furnace, and evaporate it by the heat of the spirit-lamp, to about one-third or one-half of its bulk. The tincture will, during this process, recover its original blue colour, because the carbonic acid gas becomes volatilized and the litmus is left behind in its natural state.

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of these tubes are usually kept in the Laboratory, arranged in a wooden stand; and are of great utility to the chemical operator. They will bear heat without cracking.

## EXPERIMENT III.

To show the extreme sensibility of this test, with regard to carbonic acid; let a few ounces of distilled water be tinged slightly blue, by tincture of litmus, and blow through the coloured water, the breath from the lungs, by means of a quill or tobacco-pipe, dipping into the fluid. The bubbles of air expired, whilst passing through the water, will speedily produce the reddening effect; though the quantity of carbonic acid gas contained in the air breathed out from the lungs, does amount only to 8 or  $8\frac{1}{2}$  per cent. If the water thus reddened be boiled, its original blue colour will re-appear, as in the before mentioned experiment.

## EXPERIMENT IV.

Let fall into a test tube half filled with distilled water, a drop of lemon juice, vinegar, or any of the acids contained in the chest, and add to the mixture a few drops of

tincture of litmus ; the tincture will instantly become changed to red ; boil this fluid as before directed, and its colour will not vanish, but remain permanent, because the redness is owing to a fixed acid.

#### EXPERIMENT V.

Add to the same quantity of distilled water, a grain of alum, salt of sorrel, or cremor tartar ; no change will take place ; but if a few drops of tincture of litmus be added, the fluid instantly becomes red ; because these salts contain a portion of a free or uncombined acid.

#### EXPERIMENT VI.

Impregnate distilled water with sulphuretted hydrogen gas, (see index the article sulphuretted hydrogen) and add to half a wine glass full of it, a little tincture of litmus. The fluid will exhibit a red colour ; boil the reddened tincture, and it will be seen that it

first loses its colour, or nearly so; but on continuing the heat, the fluid will become blue again; because the sulphuretted hydrogen gas is now volatilized.

#### EXPERIMENT VII.

To contrast the action of sulphuretted hydrogen gas, with that of carbonic acid gas, upon tincture of litmus, provide two test tubes containing dilute tincture of litmus reddened by carbonic acid, and two other tubes half filled with the same tincture, reddened with sulphuretted hydrogen gas. Drop into one of the first tubes, containing the carbonic acid water, a little barytic water, which *immediately* will produce a cloudiness, which again disappears by the addition of dilute nitric acid; and in the other tube containing the same tincture, let fall a few drops of nitrate of silver, which will produce no effect. This being done, drop barytic water also into one of the tubes containing the tincture of litmus reddened by sulphuretted hydrogen gas, no

precipitate will follow, and if nitrate of silver be dropt into the other tube, a black precipitate will instantly be produced.

It is often better, particularly in the examination of mineral waters, not to content ourselves with adding a few drops of the test, to a small quantity of the liquid, but to treat the mineral water with the Re-agents in the large way; by so doing we are enabled to observe the phenomena, which the test produces more distinctly, whilst at the same time when a precipitate is produced, as is frequently the case, we obtain of it, a quantity more convenient for extending our examination.

The following method of employing tincture of litmus in the analysis of mineral waters, is recommended by Dr. Philips Wilson, in his analysis of the malvern waters; it shows the superiority of the application of chemical tests in the large, where ever the nature of the subject will admit of it.

## EXPERIMENT VIII.

Let two glass basins of the same size with cylindrical sides and flat bottoms, of at least four inches diameter and three inches high (finger glasses, such as are used at table,) be placed on a sheet of white paper, and another sheet of white paper placed behind them, and let the observer stand between the glasses and the side from which the light comes, that he may receive the incident light reflected from behind and below the glasses. Let one of the basins be filled to about one or two inches in height with the water or liquid in which we suspect the presence of an acid, and let the same quantity of distilled water be put into the other glass basin, and to each let the same number of drops of tincture of litmus be added, taking care that the quantity of litmus be no more than is sufficient to give the slightest tinge, to shew decidedly the purple blue colour in the distilled water. By comparing the colour of the water in the two basins, a very minute quantity of acid may

thus be detected, especially by a person accustomed to use the test in this way.

Mr. Kirwan could not discover more than  $\frac{1}{12,000}$  of sulphuric acid by litmus. By the foregoing mode of using this test, it is rendered many times more sensible, as will appear from the following experiment.

#### EXPERIMENT IX.

To two ounces of water, sulphuric acid was added in the proportion of 1 to 307200. This was put in one of the glass basins placed as above; and in the other basin, two ounces of water, which, from previous experiments, had been found did not affect the colour of litmus. On dropping into both basins the same quantity of the test, the colour was sensibly redder in the basin which contained the acid than in the other; the difference was such as could be readily observed by a person accustomed to make such experiments.

When the acid was not diluted in the pro-

portion of 1 to 460800, no difference of shade could be observed. The specific gravity of the acid employed by Dr. Wilson was 1,85. which is the usual strength of the acid of commerce so that one grain of this acid contained 0,7946 grains of real acid, as nearly as can be ascertained from Kirwan's table of the specific gravity of sulphuric acid mixed with different proportions of water, and hence it therefore appears, that 0,7946 grains of sulphuric acid may be detected by the litmus when used in the manner stated, in 307200 grains of water, so that one grain of real sulphuric acid may be detected by this test in 386597 grains or 50,33 pints of water.

Tincture of litmus, when kept for several months, in a stopped bottle, loses its colour and acquires an olive brown tint; but it speedily regains its original blue colour, when the bottle is opened, and suffered to stand exposed to the air for a few minutes. If the colour of this tincture inclines too much to purple, add to it a few drops of liquid ammonia, but of this fluid no more must be mixed

with the tincture, than is barely sufficient to produce the desired effect, otherwise the sensibility of the test is impaired.

## II. LITMUS PAPER.

Paper stained with tincture of litmus, is also used as a test for detecting acids, in an uncombined state, by all of which it is reddened. If the redness is occasioned by carbonic acid gas, the paper, like the tincture with which it is stained, regains its original colour on drying, or by exposure to a gentle heat; whereas all other acids reddens it permanently.

Water impregnated with sulphuretted hydrogen gas, likewise produces an evanescent feeble redness with this test.

## EXPERIMENT X.

Dip a piece of litmus paper into distilled water, and its blue colour will not be altered.

Dip a piece of the same paper into water impregnated with carbonic acid gas, (or into

common seltzer water of commerce) the water will acquire a reddish tint, and in a few minutes the blue colour of the paper will also be changed to red. Remove the paper and dry it near a fire, and its original colour will re-appear, because the carbonic acid which produced the redness is volatilized.

#### EXPERIMENT XI.

Add a few drops of Sulphuric, nitric, or muriatic acid, to half a wine glass full of distilled water, and dip into the fluid a slip of litmus paper. Its blue colour will in a like manner be changed to red.

Take the paper out of the water and dry it in a warm place; its original blue colour in this case will not re-appear, because the acid which produced the redness can not be volatilized by mere heat.

#### EXPERIMENT XII.

Immerse a slip of litmus paper into any sort of wine, cyder, perry, ale, porter, or

other kind of fermented liquor, its blue colour will become changed to red, because all vinous fluids, even the mildest contain a portion of a free acid; some more, others less. The paper thus reddened will not become blue again on exposure to heat. The redness occasioned by vinous liquors in tincture of litmus, is owing to the presence of citric, tartaric, malic, or acetic acid.

#### EXPERIMENT XIII.

Dip a piece of litmus paper into water strongly impregnated with sulphuretted hydrogen gas; its blue colour will gradually be changed to a faint red, dry the paper, and its original colour will re-appear.

Paper stained with the juice of the violet flower, or the scrapings of purple radishes, answers the same purpose.

The colour of litmus paper ought to be a pale, not dark, violet blue. This paper when long kept exposed to the contact of air and light, loses its colour, and then becomes unfit

for use. It should therefore be preserved in opaque stopped bottles, or placed between the leaves of a book.

Litmus paper is readily prepared, by dipping fine writing paper into tincture of litmus, and suffering it to dry slowly. The paper employed should first be freed from the portion of glue, alum, and other foreign matters, which all writing paper contains, which may be done by a repeated affusion of distilled water.

This test paper is reddened by water, containing  $\frac{1}{4000}$  part of sulphuric acid.

### III. LITMUS PAPER REDDENED BY VINEGAR.

Litmus paper when slightly reddened by an acid, has its blue colour restored by alkalies their carbonates, and alkaline earths, because the acid which caused the redness, is again neutralised, and consequently its action destroyed; so that in this instance as usual, acids and alkalies are in direct opposition to

each other, the acid restoring the colour to its original state, after it has been changed by the alcali, and *vice versa*. A single coloured test paper of litmus becomes therefore a delicate test, for both, acids and alkalies.

To know whether the effect which this paper suffers, be owing to an alcali, or to lime, dissolved in carbonic acid, it is necessary that the fluid, be evaporated to at least one half of its original bulk, before the test paper is applied; because the excess of carbonic acid, with which lime can only exist in solution, becomes then volatilized, and the lime combined with a smaller portion of carbonic acid, can no longer exist in the liquid, but is precipitated in the form of a white powder, or neutral carbonate of lime: the heat applied having annihilated the bond of union which existed between the neutral carbonate of lime, and the excess of carbonic acid.

But if the blue colour of this paper still continues to re-appear, after the liquid has been concentrated by boiling, there is then

reason to believe, that the reddening cause is owing to a fixed alkaline salt. The nature of which may be discovered by tests employed for discovering these bodies; and the action of barytes and strontia may be rendered obvious by other means.

#### EXPERIMENT XIV.

To one-quarter of a pint of distilled water, strongly impregnated with carbonic acid gas, (or to common seltzer water) add about 15 or 20 grains of finely pulverised white marble or chalk; let the mixture stand for some hours closely corked, and shake the bottle frequently during that time. Part of the calcareous earth, of the marble or chalk, will become dissolved in the water. When the fluid has become clear, decant part of it, or better filtre it, and immerse into the solution a piece of litmus paper reddened by an acid; the tint of the paper will gradually vanish, and its original blue colour will re-appear.

## EXPERIMENT XV.

Take another portion of the same water, and evaporate it, by means of the lamp-furnace, to at least one half of its bulk. During this process it will become turbid, a multitude of minute air bubbles will become disengaged, and the carbonate of lime which was dissolved in the water by virtue of its excess of carbonic acid gas, becomes again precipitated in the form of a neutral carbonate of lime, when the excess of the carbonic acid is volatilized.

When the precipitate has subsided let the water be filtered, and immerse into it a piece of reddened litmus paper; the colour of which now will no longer be altered.

## EXPERIMENT XVI.

To a test tube full of distilled water, add a few grains of sub-carbonate of potash, soda, or any other alcali, and dip a piece of reddened litmus paper into this solution; immediately

the red colour of the paper will vanish, and its original blue colour will re-appear. Evaporate another portion of the same water, to one half of its bulk, and examine it again with the reddened paper; notwithstanding the evaporation, the red colour will disappear, and the blue be restored.

#### EXPERIMENT XVII.

Dip a piece of litmus paper slightly reddened with an acid, into half a wine glass full of distilled water, to which previously a few drops of liquid ammonia have been added; the red colour will vanish, and the paper regain its original blue colour. Remove the paper near a fire, the blue colour will now disappear, and the red colour become restored.

#### EXPERIMENT XVIII.

Litmus paper reddened by an acid, has also its colour restored by alkaline earths, namely, by barytes, strontia, &c. as may be

seen by dipping the paper into barytic water, &c. To discriminate whether the change be owing to one of these bodies, or to the action of alkalies, or carbonate of lime with excess of carbonic acid, add to the solution largely diluted with distilled water, a drop of sulphuric acid, which will occasion a precipitate if the effect be owing to the presence of barytes or strontia, for these bodies instantly produce with sulphuric acid an insoluble precipitate; whereas carbonated alkalies, namely, potash, soda and ammonia, as well as lime, are not effected by it.

This test paper also suffers a change after long exposure to air and light. It may be easily prepared by adding vinegar, or any other acid, to tincture of litmus, just in sufficient quantity, and no more, to change the blue colour of the tincture red, and then staining paper with it, as directed page 22; or by passing blue litmus paper through distilled vinegar.

## IV. TINCTURE OF RED CABBAGE.

This tincture which is of a bright blue colour, is an exceedingly delicate test both for acids and alcalies, when present in an uncombined or free state. A very minute portion of any alcali, changes its vivid blue colour, to green, whilst acids turn it red. The alkaline earths barytes, strontia, and lime, here also act as alcalies.

## EXPERIMENT XIX.

Add to half a wine glass full of tincture of red cabbage, a small quantity of the white of an egg, either in a liquid state, or rendered concrete by boiling. The tincture will lose its blue colour and become changed to green, because the white of the egg contains soda.

## EXPERIMENT XX.

Let distilled water be tinged blue, by adding to it tincture of cabbage, and fill with this coloured fluid two test tubes, Drop into

one of them a little lemon or orange juice, which will instantly change the blue colour red, and by adding the minutest quantity of subcarbonate of potash, or any other alkali (contained in the chest,) to the other tube, the blue becomes changed to green.

The action of barytes, strontia, and lime, need not to be illustrated, because they act precisely like alkalies upon this tincture, and we are in possession of excellent tests for discriminating these bodies, as will be seen hereafter.

Tincture of cabbage is very liable to spoil ; it soon undergoes a kind of putrefaction, which destroys its colour. It is obtained by cutting fresh leaves of the red cabbage (*brassica rubra*) into small pieces, and pouring over it boiling-hot distilled water and suffering the whole to macerate for a few hours. The clear fluid being then decanted and mixt with one-eighth of its bulk of spirit of wine, is fit for use.

The cabbage leaves may be preserved for many years, by drying them in a warm place,

at a temperature of about 120° F, having previously cut them into small pieces.

To prepare the test liquor from the dry leaves, let them be digested in distilled water, to which a minute portion of sulphuric acid has been added, which will produce a red tincture. Then let the acid be neutralized by marble powder, the red colour will vanish, and the tincture become blue. This being done, suffer the mixture to become clear by subsidence, or filtre it; and lastly, mingle it with one-eighth of its bulk of spirit of wine. The test thus prepared keeps much longer than when obtained from the fresh leaves of the plant.

V. TINCTURE OF BRAZIL WOOD,  
AND  
BRAZIL WOOD PAPER.

Tincture of Brazil wood, which is of a fine dark red colour, becomes changed to violet or purple, by alcalies, either in a pure state, or when combined with carbonic acid; and also by alkaline earths. It is, however, liable

to mislead, because a solution of magnesia, or calcareous earth, with excess of carbonic acid, produces a similar change. If, therefore, the test be employed in the analysis of a mineral water, containing supercarbonate of lime, or magnesia, these substances should first be got rid of, by concentrating the water by boiling, or the excess of the carbonic acid which held these earths in solution flies off, and the neutral carbonates fall down, see page 23. If the test be then applied to the filtered water we may know whether the change of colour is produced by a free or uncombined alcali, or by a carbonated earth. If by the former, the purple colour becomes more intense, because the evaporated water holds a greater quantity of alcali in solution than it did in its natural state; but if the change be produced by a carbonated earth, the effect will be the reverse. Besides this, gypsum, or sulphate of lime, is also capable of altering the colour of this test. The paper coloured with tincture of Brazil wood is usually employed instead of the tincture, it being more convenient for use.

## EXPERIMENT XXI.

Into distilled water dip a piece of Brazil wood paper; its red colour will not be altered.

## EXPERIMENT XXII.

Add to half a test tube full of the same water, a grain of subcarbonate of potash, or any other alcali, and into this solution immerse a slip of Brazil wood paper. Its red colour will instantly be changed to violet.

## EXPERIMENT XXIII.

Dissolve in distilled water impregnated with carbonic acid gas, some calcareous earth, for example powdered chalk, or marble, see page 24, and let the water stand to settle. Put into the clear solution of carbonate of lime in carbonic acid, a piece of Brazil wood paper and the red colour will gradually be changed to a very pale violet.

Let another portion of the same water be evaporated to one half of its bulk, and when cold filtre it; and dip into the filtered fluid Brazil wood paper, which now no longer will suffer a change of colour.

#### EXPERIMENT XXIV.

Shake up for a few minutes, 20 or 30 grains of chalk or marble powder, with 2 or 3 ounces of distilled water, to which previously 2 or 8 drops of sulphuric acid have been added. Part of the chalk becomes dissolved in the sulphuric acid, and the water will contain sulphate of lime. After the solution has been suffered to stand for five or six hours, or till it is clear, let it be filtered, and dip into it a piece of Brazil wood paper, the colour of which will be changed to a faint violet.

#### EXPERIMENT XXV.

Add to half a test tube full of distilled water, a few drops of liquid ammonia, and

let fall some drops of this fluid upon a slip of Brazil wood paper. It will produce brown stains, which will vanish again when the paper is held near the fire ; because the ammonia becomes volatilized.

Brazil wood paper when rendered violet by a dilute solution of an alcali, may be used as a test for acids, which cause the original red colour to re-appear.

#### VI. TINCTURE OF TURMERIC,

AND

#### TURMERIC PAPER.

This is an excellent test for discovering the presence of alcalies. The colour of the tincture is an intense yellow ; it is changed to a brick red, or orange, by alcalies, whether in a caustic state or combined with carbonic acid, but it is not effected by carbonated earths ; so that by this test we are at once enabled to distinguish the presence of a carbonated alcali, from a carbonated earth, when held in solution by an excess of carbonic acid.

Paper stained a pale yellow with this tincture, being more convenient in its application than the tincture itself, is usually employed in the laboratory. By means of it, the exact point of saturation of acids with alkalies may be ascertained with great nicety, which is often of considerable consequence in chemical operations.

#### EXPERIMENT XXVI.

Dip a piece of turmeric paper into distilled water, its yellow colour will remain unaltered.

#### EXPERIMENT XXVII

Add a grain of potash, or soda, either in a pure state, or in the state of a carbonate, to half a test tube full of distilled water, and immerse into the solution a piece of turmeric paper, it will instantly acquire a brown colour; and if the paper be now dipped into a dilute acid, its original yellow colour will reappear.

## EXPERIMENT XXVIII.

Hold a piece of turmeric paper, slightly wetted with distilled water, over the open mouth of the bottle (in the chest) containing liquid ammonia. The colour of the paper will become changed to brown, remove the paper, and hold it near the fire, the brown colour will vanish, and its original yellow colour will re-appear ; because the ammonia becomes volatilized.

## EXPERIMENT XXIX.

To seltzer water, (or distilled water impregnated with carbonic acid gas) add a portion of marble powder or chalk, shake the mixture in a stopped phial frequently, during the space of twelve hours, to effect a solution of carbonate of lime ; and lastly, filtré it or suffer the mixture to stand undisturbed till it is become transparent. Dip into this solution of super-carbonate of lime, a slip of turmeric paper ; its yellow colour will suffer no

alteration. Hence this test paper is not changed to orange by carbonate of lime, but only by carbonated alkalies, and on this account it is preferable to Brazil wood paper, (page 31). Barytes, strontia, and lime, act, as stated already, in this case also like alkalies.

The action of turmeric paper is very great, as may be seen from the following statement which is copied from Dr. P. Wilson's analysis of the Malvern waters, p. 32.

### EXPERIMENT XXX.

" Half a grain of carbonate of soda, was  
" dissolved in twelve ounces of distilled  
" water, which were heated to 136°. Paper  
" stained with turmeric was allowed to re-  
" main in it for one minute at this tempera-  
" ture. Its colour was not at all altered.  
" This water was gradually evaporated at a  
" temperature never exceeding 140°. and at  
" short intervals slips of paper stained with  
" turmeric were dipped into it and allowed to  
" remain in it exactly a minute, and as soon

“ as the tinge it gave to the paper was decidedly orange, it was removed from the fire and measured; at this time the temperature was 124°. The quantity of water was found to be nine ounces.

“ Four ounces of Holy-well water were heated to 136°; at this temperature it did not affect the colour of paper stained with turmeric, when allowed to remain in it one minute. The evaporation was continued in a temperature never exceeding 140°, and gradually lessened to 124°, the slips of paper being used at short intervals as before. When a decidedly red tinge was observed, on allowing the paper to remain in it for a minute in a temperature of 124°, it was removed from the fire and measured: it was found to have lost just one fourth. From this experiment it is evident the quantity of carbonate of soda in a gallon of Holy-well water was easily calculated. The result is 5,33 grains.

“ Half a grain of carbonate of soda was dissolved in eleven ounces of distilled water,

and exposed to a temperature of 115°. The paper stained with turmeric immersed into it; but I now measured the water as soon as the least discolouration appeared in the paper, after it had remained in it for a minute in the above temperature, and found the quantity to be ten ounces and a half.

“Four ounces of Holy-well water discoloured the paper, allowed to remain in it for the same length of time, in the same temperature, when one eighth was evaporated. I was surprised on making the calculation, to find that this experiment gave precisely the same result as the preceding 5,33 grains of carbonate of soda in a gallon, of water, that is, 128 ounces, and which quantity of alcali was thus detected by turmeric paper.”

Turmeric paper rendered brown, or orange by alkalies, is restored to its original yellow colour by acids.

EXPERIMENT XXXI.<sup>1</sup>

Dip a piece of turmeric paper into water, to which a little liquid ammonia has been added, the paper will become brown, remove it into water acidulated with sulphuric, nitric acetic or muriatic acid, and its yellow colour will be restored.

Instead of turmeric paper, a fresh cut surface of the entire turmeric root may be wetted with distilled water, and by being rubbed on white paper, a very visible yellow mark will be made, on which a drop of the liquor to be examined may be put.

## VII. SULPHURIC ACID.

Highly concentrated sulphuric acid discovers by a brisk effervescence, carbonic acid gas, when present in an uncombined state in any liquid, or when in combination with an earthy, alkaline, or metallic base. It is likewise used, for decomposing the salts of lead and mercury, with which it produces a white

precipitate. The precipitate obtained with mercury acquires a yellow colour by the affusion of boiling water. It is also a capital test for barytes and strontia, with both of which it forms highly insoluble compounds. This acid is frequently employed in analytical experiments, for ascertaining the nature of certain classes of salts, so far, at least, as to discover the nature of the acid with which the base of the salt is united. But when used for that purpose, it is necessary that the saline compound to be examined, be in a solid state, or at least nearly so. The salt to be assayed is covered with sulphuric acid, and the mixture warmed a little, a vapour or cloud will thus be produced; because the sulphuric acid expels the nitric muriatic, acetic, and fluoric acids, (besides many others) from their combinations. And as these acids are capable of assuming the gaseous state, and are condensable by moisture, they produce vapours, with the moisture of the atmosphere; and from the nature of these vapours, the nature of the acid may be learnt. For ex-

ample: If the salt belonged to the class of nitrates, the vapours produced by the action of the sulphuric acid have a yellow or orange colour, and the salt, then deflagerates when laid on ignited coals. If the salt belongs to the class of muriates, the vapours are white; if it belongs to the class of acetates, the vapours have a strong smell of vinegar; and if they corrode glass, when suffered to be in contact with it, for 10 or 20 minutes, the salt contains fluoric acid. Other tests may then be applied, to confirm or destroy the conjectures thus obtained by this agent. Sulphuric acid has also been recommended as a test for lime, when it exists in combination with certain bases, but it is of little value for that purpose, because the sulphate of lime which it produces, being soluble in 500 parts of water, and much more so, when there is an excess of acid. When employed for that purpose, the solution when highly concentrated is suffered to cool, the sulphate of lime then separates in long transparent crystals, which is a very common form for it to

occur in chemical analyses. It is then distinguished by its want of taste, its difficult solubility when removed into pure water, and by its affording a precipitate with oxalic and barytic salts. When a liquor containing selenite is rapidly evaporated, this salt separates as a brittle shining laminae.

#### EXPERIMENT XXXII.

To half a wine glass full of distilled water, add about 20 or 30 drops of sulphuric acid, and stir the fluid with a glass rod, the mixture will take place quietly, and no air bubbles become disengaged.

#### EXPERIMENT XXXIII.

Into the same quantity of water impregnated with carbonic acid gass, or to common seltzer water, add a like quantity of sulphuric acid. A multitude of very minute air bubbles will rapidly become disengaged, which indicate the presence of carbonic acid gas.

## EXPERIMENT XXXIV.

Having dissolved 10 or 15 grains of muriate of soda (common salt) in about two tea-spoonfuls of water, add to it 10 or 15 drops of sulphuric acid. White fumes will be disengaged; which indicate the presence of muriatic acid. And if a glass rod, or a feather, moistened with liquid ammonia, be brought near the mixture, the fumes will become more visible, and dense white clouds will be produced in the vicinity of the body, moistened with the liquid ammonia. The sulphuric acid decomposes the common salt, and expels one of its constituent parts; namely, the muriatic acid; which as it becomes liberated, assumes the gazeous form, and would be invisible, if no humidity was present. But being condensed by the moisture which it meets with in the atmosphere, it appears as a cloud. The liquid ammonia producing dense white clouds, is owing to the production of muriate of ammonia, a salt, formed from the vaporous muriatic acid, combining

with the volatilized ammonia, and thus producing muriate of ammonia.

## EXPERIMENT XXXV.

Put into a small evaporating basin, 10 or 12 grains of pulverised nitrate of potash, (saltetra) and pour upon it 20 or 25 drops of sulphuric acid; stir the mixture with a glass rod, and warm it gently over the spirit lamp. Yellow fumes will be produced, which indicate the presence of nitric acid. If a little of the salt be thrown on ignited coals, it will effervesce.

## EXPERIMENT XXXVI.

Put 10 or 20 grains of super-acetate of lead, or acetate of potash, into an evaporating basin, or tea-cup, and moisten it with sulphuric acid; a strong odour of vinegar, will immediately become predominant, because the sulphuric acid expels the acetic acid, from the super-acetate of lead, and unites with its base to produce sulphate of lead.

## EXPERIMENT XXXVII.

Take common fluor spar (Derbyshire spar) reduced to powder, put about 1 ounce or more of it into a leaden basin (a piece of common sheet lead turned up at the edges so as to form a rim, will answer the purpose) make it into a liquid paste with common sulphuric acid, and then heat the mixture over the lamp. Dense white fumes will become disengaged; and if a plate of glass be laid over the basin, it will speedily loose its polish, and become corroded by the vapour, or disengaged fluoric acid gas. In this manner etchings on glass may be made. The glass is to be covered over with hard engravers varnish, called, etching ground, or bees-wax will answer the purpose, for the sake of experiment. When the coating is dry, the design intended to appear upon the glass, is traced out upon the varnish or wax by means of a needle, or other sharp pointed instrument, as is done in common copper-plate etching; taking care that every stroke, or line, is carried

an, and smooth, through the coat of varnish wax down to the surface of the glass, so that light may be seen through the traces or pits. If the glass thus prepared, be exposed to the volatilized fluoric acid gas, by laying it over the basin, the etching will be made in 5 to 10 minutes.—The varnish or wax may afterwards be removed, by oil of turpentine.

The fluor spar consists of fluoric acid, titrated to lime, on adding to it sulphuric acid which has a stronger affinity for lime, than the fluoric acid has, the latter becomes disengaged in the gaseous state, and corrodes the glass in those parts where the varnish does not defend it, from its action.

### VIII. NITRIC ACID.

This acid is employed as a test, for ascertaining, in an expeditious manner, the purity of tin, for which purpose it is employed in the concentrated state; and when largely diluted with water, it becomes a test for readily distinguishing iron from steel. In the

analysis of vegetable substances, the concentrated nitric acid, assists us to discover *Resin*. For when concentrated nitric acid is digested repeatedly, with gum or mucilage, gluten, jelly, extract, gum-resin, or any other of the immediate vegetable products, it converts them into oxalic acid; whereas true Resin, suffers no such change; and even after long digestion, this substance becomes only converted by means of nitric acid, into a pale, porous orange coloured mass. And if nitric acid be repeatedly abstracted from it, the result is not oxalic acid, but a deep orange coloured substance, which is soluble in water, and in alcohol: and although the resinous properties being lost, no vestige of oxalic acid can be discovered in the solution. Nitric acid is also used, to detect starch in vegetable substances. The substance is to be digested for some days in dilute nitric acid, and the solution mingled with alcohol; which throws down the starch from its solution in this acid. [Ann. de Chem. l. v. 28.]

And in the analysis of organic substances

In general, nitric acid serves the purpose of a test for detecting the presence of azote or nitrogen, and thus it enables us to establish the presence of animal matter; because when this acid is made to act without the assistance of heat, upon a substance the nature of which is to be determined in that respect, azote, or nitrogen, is produced. For in fact we are not acquainted with any other ready method of discriminating in analysis, animal matter, from vegetable matter; because we possess no other means of extracting azote, perfectly insulated state. The elements of animal matter are peculiarly prone to combination, and among them particularly the azote. The substance requires simply to be heated in a retort, and the gazeous product to be collected in the usual manner. That the nitric acid, did not furnish the azote, may be proved by saturating an aliquot portion of the acid employed in the experiment with an alcali, for it will be seen that the portion of acid thus dried, saturates as much alcali, as a like portion of the same acid, which has not been

made to act upon the substance, consequently the azote must have been produced from the substance submitted to the action of the acid. Nitric acid is likewise useful as a test, for detecting uric acid, (in the analysis of urine) it produces with this substance a pink or rose colour.

### EXPERIMENT XXXVIII

Tin of commerce, frequently contains either a minute portion of copper or lead, and sometimes both these metals are present. To ascertain the purity of tin by means of nitric acid, put one part of the filing of the suspected metal, into a basin or other convenient vessel, and add to it about three or four parts of nitric acid, a very violent action becomes exerted, the acid is decomposed with great rapidity, copious red fumes are disengaged, and the temperature of the mixture rises considerably. The tin becomes so highly oxidized, that it does not pass into a state of solution, but forms a white powder, in which, after having been washed, there are no traces of

tric acid, and which is therefore nearly a pure oxide.

When this has been effected, pour a small quantity of distilled water upon the mass, stir the mixture together, and suffer it to stand undisturbed, (or filtre it) till the super-natant liquid is become clear. Decant the clear fluid, and add to it liquid ammonia in excess; if the iron contained copper the fluid now will assume a blue colour. To assay it for lead, add to another portion of the clear fluid, a few grains of sulphate of soda dissolved in water, which will occasion a white precipitate if lead be present, (sulphate of lead) which is highly insoluble in water, and therefore falls to the bottom.

#### EXPERIMENT XXXIX.

To distinguish iron from steel by means of this test, let the acid be diluted, with so much water that it will only feebly act upon the blade of a common table-knife. If a drop of the acid thus diluted, is suffered to fall upon steel, and allowed to remain upon it for a few mi-

nutes, and then washed off with water, it will leave behind a *black* spot. But if a drop of this acid, be suffered to act upon iron, in the same manner, the spot, will not be black, but of a whitish grey colour. The black stain, is owing to the conversion of the carbon of the steel into charcoal, which thus becomes predominant, and iron being nearly free from carbon can produce only a grey stain.

The utility of this test, is not confined to finished articles manufactured of steel, but its application enables the workmen in iron and steel, to ascertain also the *quality* and *uniformity* of texture of *unfinished* articles. The following observations of Mr White show the utility of the test, to the workmen in steel and iron in general.

“ It very frequently happens, that articles  
“ of considerable value, intended to be fabri-  
“ cated in iron or steel, are not known to be  
“ defective until much expense has been in-  
“ curred in manufacturing them. A piece of  
“ iron which has a vein of steel running  
“ through it, as is too often the case, will re-

ppuire at least three times the labour and care to turn out to be fashioned in the lathe which would have been demanded by a piece of greater uniformity. Steel which abounds with spots, veins, or specks, will not show its defects until the final operation, when the attempt is made to finish and to polish the work. Other articles of steel, such as delicate measuring or micrometer screws, blades of the best kinds of sheers, fine circular cutters, engraver's tools, surgical instruments, &c. either bend and lose their shape in the hardening, from the difference of expansion, or resist the tool when wrought in the temperal state, or exhibit other incurable defects when they come to be tried, which the test by dilute nitric acid would have indicated before any expence had been incurred. In these and in numberless other instances, it would have been incomparably more advantageous, to have rejected the material upon the first trial, than have proceeded to the very expensive process of manufacturing the article, and

" then finding it of no value. By this means  
" I have seen bars of steel, which were war-  
" ranted by the vender as perfect, as full of  
" veins and irregularities as the coarsest wood,  
" and have been enabled to select the best  
" and most uniform pieces for works of the  
" greatest delicacy; whereas, without this  
" process, I have very often had the mortifi-  
" cation to fail in the last stage of processes  
" upon which much cost and labour had been  
" bestowed. It is only necessary to clean  
" the rough article with a file, or emery  
" paper, and then to apply the nitric acid in  
" a very dilute state; the parts which contain  
" the greatest portions of carburet of iron  
" will immediately show themselves by their  
" dark colour." *Repository of Arts*, No. iv.  
page 202. 1816.

#### IX. MURIATIC ACID.

This acid may be used for detecting the presence of silver and lead, with the solutions of which it forms a white precipitate. The precipitate produced with silver, becomes

nickly blackened on exposure to light, it is perfectly insoluble in water, and soluble in liquid ammonia. The precipitate occasioned by lead, suffers no such changes: it is soluble in about 22 parts of boiling water, and in dilute nitric acid.

It is also employed, for discovering ammonia, when in a disengaged state; a glass rod or other substance, moistened with this acid, if held in the atmosphere of ammoniacal gas, becomes immediately surrounded by dense white clouds of muriate of ammonia, see page 44. It is likewise an useful auxiliary agent for ascertaining the presence of oxide of manganese, in mineral substances; because it produces with it chlorine gas. Suppose a mineral be presented to us, and we wish to know whether it contains a notable quantity of oxide of manganese, we may proceed in the following manner: 1st, Reduce the mineral to powder, pour upon it aqua regia, and apply a moderate heat. If chlorine gas be disengaged in abundance, the mineral is chiefly manganese. 2d. To be

certain of this, melt a little borax or soda in a platina spoon, add to it a little of the ore, and keep it melted by the *interior* flame of the candle. The colour of the mass in the spoon will be at first red, but this colour will gradually disappear if the ore be manganese. Now add a little nitre, or keep it melted for some time in the *exterior* flame, and the red colour will again appear, see Annals of Philosophy 1814, xxvi. p. 312.

#### EXPERIMENT XL.

Mix 5 or 6 drops of super-acetate of lead, with half a wine glass full of distilled water, and add to it, a drop or two of muriatic acid; a dense white precipitate will fall down, which is muriate of lead. This salt being soluble in about 22 parts of water, in which latter respect, as well in not changing colour by a short exposure to light, it may be distinguished from muriate of silver, (see nitrate of silver,) which it resembles; and water may therefore be used to separate the muriate of lead from that of silver, but nitric acid is pre-

wable. The muriate of lead is likewise soluble in acetic acid, by which it may further be distinguished from muriate of silver, and from sulphate of lead. According to Klaproth, 100 grains dried fully, but short of volatilization, contain 75 of lead and 14 of muriatic acid.

#### EXPERIMENT XLI.

Mix a few grains of muriate of ammonia with double its weight of sub-carbonate of potash, or quick lime, intimately together, and holding near it a feather, or glass rod, moistened with muriatic acid, dense white fumes will become visible, which indicate the presence of ammonia. See page 44.

#### EXPERIMENT XLII.

Add a few drops of liquid ammonia, to half a test tube full of distilled water, and moisten with this fluid, a piece of paper, or any other substance. If a glass rod, or fea-

ther wetted with muriatic acid, be now made to approach the paper, dense white vapours will be formed.

For the action of muriatic acid, as a test for silver, see nitrate of silver.

#### X. TARTAREOUS ACID.

The two alcalies, namely, soda and potash resemble each other so closely in their most obvious chemical characters, that they are not readily distinguishable than by studying the characters, of their combinations: namely, by uniting them to acids and examining the salts resulting from this combination. Thus sulphate of potash is a hard bitter salt, requiring a large quantity of water for solution, and therefore a saline precipitate of sulphate of potash is formed when the acid and alkaline solutions are somewhat concentrated, when mixt: whereas sulphate of soda is very soluble. Nitrate of potash crystallizes in long six-sided prisms, but nitrate of soda in cubes.

however by means of tartareous acid this trouble may be saved, for it produces with potash when added in excess, a highly insoluble salt, but with soda a salt which is easily soluble in water. The alkali to be examined first dissolved in muriatic or any other acid, and a solution of tartareous acid added in excess, if the salt has potash for its basis, there will be a crystalline precipitate in a few seconds, but the mixture will remain clear if the basis of the salt is soda. But for the successful action of this test, it is necessary that the solutions of the salts be as concentrated as possible, and that the tartareous acid be always added in excess.

#### EXPERIMENT XLIII.

Make a concentrated solution of sulphate of soda in distilled water, and add to it a concentrated solution of tartareous acid; no change will take place, because the salts of soda are not altered by tartareous acid.

## EXPERIMENT XLIV.

Make a concentrated solution of sulphate of potash in water, and add to it, tartareous acid in excess ; a crystalline salt will gradually collect and fall to the bottom of the tube. The salt, is super-tartrite of potash.

## EXPERIMENT XLV.

Drop tartareous acid into a solution of phosphate of soda, no change will take place, for the same reason as stated in Experiment XLIII.

## EXPERIMENT XLVI.

Add to a solution of prussiate of potash, tartareous acid, and suffer the mixture to stand for a few minutes ; minute crystals of super-tartrite of potash will be deposited on the sides of the vessel.

## EXPERIMENT XLVII.

Dissolve five or six grains of caustic soda, in half a test tube full of water ; and add to

In solution, tartareous acid in excess, no change will take place.

## EXPERIMENT XLVIII.

Dissolve the same quantity of caustic potash in a like quantity of water; and add to the solution tartareous acid, in a few seconds the mixture will become turbid, and a quantity of white granular powder will fall to the bottom, which is super-tartrite of potash, and may be distinguished as such (when rinsed with cold water) by feeling hard and granular in the mouth, with a slightly acidulous taste.

## XL. BORACIC ACID.

The Boracic acid is employed in analytical chemistry, not directly as a re-agent or instrument of analysis, because, its affinities and action have little energy compared with other acids. But it is of use to the mineralogist, as a flux for the blowpipe assay; it particularly facilitates the fusion of earthy

substances ; and produces with them, a very limpid fusion. It is not volatilized by the most intense heat, and the mass which it affords with a vast number of mineral substances, does not readily sink into the pores of the charcoal upon which the assay is made. It may even be mixt with charcoal powder, without producing an incomplete vitrification. It is capable of dislodging all the acids, except the phosphoric, from their combinations, and at the same time from the colour which it produces, with different metallic oxides &c. some conjecture may be formed, concerning the nature of the substance upon which it is made to act.

It is likewise a very useful agent for discovering the presence of alkalies in mineral substances, and has been recommended particularly for that purpose by Sir Humphrey Davy. He fuses one part of the mineral under examination with two parts of boracic acid, dissolves the fused mass in dilute nitric acid, and concentrates the solution to separate the silex. The liquid is then mixed with carbo-

sate of ammonia in excess, boiled and filtered. By this means all the earthy and metallic ingredients are separated. The liquid is next mixed with a sufficient quantity of nitric acid, and evaporated till the whole of the boracic acid is separated. Nothing now remains but the nitric acid, combined with the alkaline constituents of the mineral, (and with ammonia) the nature of which may then be readily ascertained by tartareous acid, or muriate of platina, the nitrate of ammonia being first got rid of by an exposure to a dull red heat.

## XII. ACETIC ACID.

Is occasionally employed as an auxiliary test for detecting the presence of ammonia in the manner stated, page 44. Acetic acid is of particular use in the analysis of vegetable substances, to separate resin from gluten, both of which are dissolved by acetic acid, but the latter remains in solution when water is added, and the former becomes precipitated. And as this acid does not, like the sul-

phuric and nitric acid, alter the resin when digested with it even for a considerable time, but lets this substance fall again apparently unaltered by the admixture of water, it affords a very useful re-agent in the complicated analysis of vegetable substances.

### XIII. OXALIC ACID.

The oxalic acid is a test in chemical experiments to determine the presence of lime in liquids, in whatever combination this earth exists; for it attracts lime with greater force than any other acid, and therefore is capable of decomposing compleatly all the known calcareous salts. The oxalate of lime is insoluble in water; so that when this acid is added to a solution containing lime, a white precipitate of oxalate of lime falls down, from which, when collected, washed, and dried in a moderate heat, the actual quantity of lime may be readily inferred. But oxalate of ammonia is a better test for lime. See *Oxalate of Ammonia*.

Oxalic acid is also an useful re-agent, for separating oxid of iron from oxid of titanium; if a solution of this acid, be added to muriate of titanium, a precipitate falls down, which is a pure oxalate of titanium, and which may be decomposed by exposure to a heat, sufficient to destroy the oxalic acid. This acid may likewise be employed for separating oxid of iron, from oxid of cerium. If these two oxids exist together, it is only necessary to boil them in a solution of oxalic acid; the oxid of iron becomes dissolved, and the oxid of cerium remains behind in the form of a white powder, as oxalate of cerium; which may then be decomposed by heat. M. Laugier. Ann. de Chemie, t. 89, p. 306.

#### XIV. MURIATE OF AMMONIA.

This is one of the tests employed for detecting platina, with the solution of which it produces (if the platina be pure) a bright yellow precipitate, very slightly verging to

orange. The precipitate is a triple compound, consisting of oxide of platina, ammonia, and muriatic acid. And by this character platina is distinguished from all other metals ; and may be separated when combined with them. The precipitate, or triple-salt, obtained by muriate of ammonia, when exposed to a strong red heat, furnishes a grey spongy mass, which is metallic platina.

This test therefore furnishes a ready expedient for detecting the adulteration of gold with platina, which would elude the hydrostatic trial. The gold may be precipitated by a solution of green sulphate of iron, (See sulphate of iron) and the platina, by muriate of ammonia.

When this test is added to a solution of the *ore of platina*, in nitro-muriatic acid, the precipitate afforded by the first addition of muriate of ammonia, is of a buff colour ; and if the fluid above it, which is still of a reddish brown colour, be poured off ; and muriate of ammonia again be added to it, a precipitate is thrown down of a bright orange colour ; but

so clear yellow precipitate can be obtained from the solution. The orange colour of the precipitate is owing to the presence of the metal called *Iridium*, which is associated with the ore of platina; a clear yellow colour of the precipitate is therefore a criterion of the purity of platina. The yellow precipitate forms an useful pigment for the painter, being very bright and permanent colour.

Muriate of ammonia is also used as a test, to detect alkalies, and alkaline earths, all of which decompose this salt, and render obvious the ammonia. For this purpose the salt must be in a dry state, or nearly so, and a moderate heat may be employed to disengage the ammonia. But as many metals, and metallic oxides, are also capable of decomposing muriate of ammonia in the dry way, some collateral proofs must be employed, to render the presence of the alkali or alkaline earths, unequivocal, besides, this we have better tests for alkalies and alkaline earths.

Mr. Chevenix recommends this salt as an useful agent for separating alumine from its

alcaline solutions; the alcali combines with the muriatic acid; and the liberated ammonia, determines the precipitation of the alumine, which after being washed and dried, is perfectly pure.

#### EXPERIMENT XLIX.

Mix a little muriate of platina with half a test tube full of distilled water, and add to the mixture a solution of muriate of ammonia, a yellow precipitate will fall down, consisting of oxide of platina, muriatic acid, and ammonia.

#### EXPERIMENT L.

Mingle a solution of muriate of platina with a solution of muriate of gold, and drop into the mixture, a solution of muriate of ammonia, till no further precipitate ensues, and suffer the fluid to stand undisturbed till the super-natant fluid is become perfectly clear; it will still have a yellow colour. Add to it, a fresh prepared solution of green sulphate

If iron, it will now again become turbid, or suddenly acquire a green colour, and a dark greenish, or rather a brown precipitate will slowly be deposited, which is metallic gold. If the precipitate obtained by muriate of ammonia be heated to redness by means of the blowpipe, or (if the quantity be considerable) in the bowl of a tobacco pipe put into a common fire, metallic platina will be obtained in the form of a grey porous mass.

#### XV. OXY-MURIATE OF MERCURY,

OR

#### CORROSIVE SUBLIMATE.

This salt of mercury is employed as a test for indicating the presence of alkalies and alkaline earths. The fixed alkalies when caustic produce with it, a yellow; and carbonated alkalies, an orange-coloured precipitate; fine water produces with it also an orange-yellow precipitate. But this salt is seldom used, for we have better tests to discover

alcalies. Its action as a Re-agent in the analysis of animal substances, is of greater value; for by means of it, we are enabled to detect minute quantities of albumen; a substance, which largely enters into the composition of many animal products. It produces with albumen, a white flocculent precipitate. It does not however separate the whole of the albumen, unless heat be employed, to assist the coagulation. And hence Dr. Bostock has proposed the following ingenious method of estimating the quantity of albumen contained in an animal fluid, viz. add to the fluid a quantity of oxy-muriate of mercury, more than sufficient to saturate the albumen, and then heat the mixture. By this double action a coagulum is formed, which may be separated by the filtre. The precipitate is a compound of the metallic salt, with albumen; in the proportion of about one of the former, to three or four of the latter. From the quantity of corrosive sublimate, therefore, required to decompose entirely a solution of albumen, we may

ffer the quantity of the latter; for three grains of the metallic salt, being entirely de-  
composed, indicate 10½ grains of albumen.

There are other tests for detecting albu-  
men; for instance sub-acetate of lead, and ni-  
trate of silver, but the sub-acetate of lead  
(Boullard's extract), and nitrate of silver, act  
so on other varieties of animal matter,  
as muriate of mercury does not. Corrosive  
sublimate likewise, may be made a test for  
detecting salts with a base of ammonia, when  
applied in the manner to be stated presently.

#### EXPERIMENT LI.

Dissolve one or two grains of sub-carbo-  
nate of potash, in half a test tube full of dis-  
tilled water, and add to it, a few drops of the  
solution of oxy-muriate of mercury; an orange  
coloured precipitate will immediately fall  
down to the bottom of the tube.

## EXPERIMENT LII.

Add to half a test tube full of distilled water, a grain or two of sub-carbonate of soda and drop into the solution ; oxy-muriate of mercury and the same effect will take place as in the preceding experiment.

## EXPERIMENT LIII.

Dissolve a few grains of caustic potash, or soda, in half a test tube full of water, and drop into the fluid, a solution of oxy-muriate of mercury ; at first a sulphur yellow precipitate will fall down, but, by increasing the admixture of oxy-muriate, the precipitate will assume a dull orange colour.

## EXPERIMENT LIV.

Half fill a test tube with fresh prepared lime-water, and add to it, a few drops of the solution of corrosive sublimate : an orange yellow precipitate will instantly fall down.

## EXPERIMENT LV

Mix a small quantity of the albumen or white of an egg, with distilled water, and suffer it to stand till the insoluble part has subsided. Decant the clear fluid, and drop into it, a solution of corrosive muriate of mercury; a milkiness will ensue, and after some time a white flocculent precipitate becomes deposited.

The same effect takes place, if serum of blood be mixed with water, or any other albuminous matter. A drop of a saturated solution of oxy-muriate of mercury when added to water containing  $\frac{1}{1,000}$  part of its weight of albumen produces a visible cloudiness: and at the end of some hours, a flocculent precipitate falls to the bottom of the vessel. The same re-agent produces a sensible effect on a liquid, containing only half that quantity, or  $\frac{1}{2,000}$  of albumen, if the mixture be suffered to stand for some hours.

This test should be kept in the dark, be-

cause light renders it turbid, a white precipitate (sub-muriate of mercury) separates; and its action is impaired.

#### EXPERIMENT LVI.

Dissolve one grain of muriate of ammonia, in a wine glass full of distilled water, and add to the fluid a single drop of a solution of potash or of soda. If now a drop or two of the solution of oxy-muriate of mercury be added, the mixture will become milky, and a white precipitate falls down, consisting of muriatic acid, mercury, and ammonia.

#### EXPERIMENT LVII.

Add one grain of nitrate of ammonia to a wine glass full of distilled water, and after having added to it also a drop of a solution of any alcali, let fall into the mixture a drop of the solution of corrosive sublimate, or oxy-muriate of mercury; a white precipitate (sub-oxy-muriate of mercury and ammonia,) will instantly fall down.

It is essential that the solution be neutral.

The delicacy of oxy-muriate of mercury, when thus applied for detecting ammoniacal salts, is extremely great. One grain of muriate of ammonia, dissolved in 16 ounces of water may be detected by it. For the application of this test we are indebted to Mr. F. Brande.

#### XVI. SUB-NITRATE OF MERCURY.

Is employed as one of the re-agents for detecting uncombined ammonia, with which it produces an ash-grey, or black precipitate. It may likewise be used for detecting muriatic acid, with which it occasions a white precipitate, one part of muriatic acid combined with 100,000 parts of water, may readily be discovered by this re-agent.

It is also an useful test for detecting not only the presence, but likewise the quantity of phosphoric acid contained in any fluid; for it produces with this acid, a white precipitate, which is soluble in an excess of phosphoric acid, and also in nitric acid, which the precipitate produced by muriatic acid is not.

The precipitate obtained by phosphoric acid, (phosphate of mercury) may be decomposed, by mere exposure to heat, and thus the phosphoric acid is obtained in a pure state. Or if the precipitate is exposed to the blowpipe heat, upon charcoal it first melts with effervescence and a green flame, into a yellowish glass; by continuing the heat the mercury is volatilised, and may be condensed in its metallic state on a plate of copper held over the vapour; the phosphoric acid then burns off into phosphorus. With a solution of muriate of gold it produces a dense precipitate, of a bluish black colour; and with muriate of platina an orange coloured precipitate.

Some precautions, however, are necessary when this test is employed for discovering phosphoric acid: namely, it is essential that the fluid should not contain any free alcali, or alkaline earth. Sub-nitrate of mercury may also be applied for discovering sulphuric acid, with which it affords a white crystalline or pulverulent precipitate, which becomes yellow when repeatedly washed with boiling water.

## EXPERIMENT LVIII.

Add to half a test tube full of distilled water, a drop of liquid ammonia, no change will take place, but if a few drops of a solution of sub-nitrate of mercury are added, an ash-grey precipitate instantly falls down to the bottom of the tube.

## EXPERIMENT LIX.

Add to half a wine glass full of distilled water, a drop of muriatic acid, or a single grain of common salt; and pour into the solution a few drops of sub-nitrate of mercury; white clouds will be produced, and a white precipitate fall down to the bottom, which will not disappear, or become re-dissolved by the admixture of nitric acid.

## EXPERIMENT LX.

Dissolve a few grams of phosphate of soda, in half a test tube full of distilled water, and

add to it, a solution of sub-nitrate of mercury; a white precipitate will fall down (phosphate of mercury). When the precipitate has subsided decant the supernatant fluid, and assay the precipitate by adding to it nitric acid, which will speedily dissolve it.

#### EXPERIMENT LXI.

Add to half a test tube full of distilled water, three or four drops of sulphuric acid, or dissolve in the water six or nine grains of sulphate of soda, and add to the fluid sub-nitrate of mercury, a dense white precipitate will take place, and speedily settle to the bottom. This precipitate by the repeated affusion of boiling hot water acquires a yellow colour.

#### EXPERIMENT LXII.

Mix with half a test tube full of distilled water, a few drops of muriate of gold, and add to the mixture, one or two drops of sub-nitrate of mercury; a bluish black precipitate will instantly be formed.

## EXPERIMENT LXIII.

Let fall one drop of muriate of platina into half a wine glass full of distilled water; and add to this mixture a drop of sub-nitrate of mercury; a bright orange coloured precipitate will fall down to the bottom of the tube.

## XVII. NITRATE OF SILVER.

The solution of silver in nitric acid, is an excellent test, for discovering muriatic acid, either in a free state, or when combined with other bodies. It produces with it, a curdy nitre precipitate, which is insoluble in water, but readily soluble in liquid ammonia, and which becomes speedily blackened on exposure to light.

The delicacy of this test is astonishingly great; one grain of common salt, dissolved in 42,250 grains of water; that is rather more than five pounds of water, is rendered vivacious by it; white clouds being produced in the fluid; and this quantity of

water, it may be proved does not contain more than  $\frac{1}{108,333}$  part of its weight of real muriatic acid.

In applying this test, certain precautions are necessary, because it is also acted on by alkaline and earthy carbonates, and by sulphuric acid and its combinations. This may be guarded against, by first removing the sulphuric acid, by nitrate of barytes; and the action of the carbonates, may be prevented, by supersaturating them previously with pure nitric acid. The precipitate produced by carbonated alkalies, (carbonate of silver) is soluble in dilute nitric acid with effervescence, the precipitate produced by muriatic acid, is not. With the assistance of an alcali, nitrate of silver becomes likewise an excellent test, for detecting minute portions of arsenic, with which it produces a yellow precipitate. It likewise indicates minute portions of sulphuretted hydrogen, and sulphurets in general, for it produces with them a black precipitate. It affords with chromic acid a carmine red precipitate.

## EXPERIMENT LXIV.

Mix a drop of muriatic acid, with a wine glass full of distilled water; and add to the mixture a drop of the solution of nitrate of silver; a white curdy precipitate (muriate of silver) will immediately be produced and fall rapidly to the bottom of the glass. 100 grains of this precipitate thoroughly dried, but not melted, contain 75,235 grains of silver; the remaining 24,765 grains consist of muriatic acid, and oxygen. It may be reduced in the following manner to the metallic state, and yields the purest silver which can be obtained.

## EXPERIMENT LXV.

Mix one part of dry muriate of silver, with three of subcarbonate of soda, or potash of commerce, freed from water, by heat; put the mixture into the bowl of a tobacco pipe, and make it red hot in a common coal fire. When the mass has been in perfect fusion for about ten minutes suffer it to become cold. On

breaking the pipe a brilliant button of pure silver will be found at the bottom of the vessel.

Nitrate of silver is used as a test by the refiners, for examining and purifying their aqua fortis, or nitrous acid. They let fall into the acid of commerce a few drops of a solution of nitrate of silver. If the acid remains clear it is fit for their use; otherwise they add a small quantity more of the solution, which immediately turns the whole of a milky white-colour; the mixture being then suffered to rest for some time, deposits a white sediment (muriate of silver) from which it is cautiously decanted, examined again, and if necessary further purified by a fresh addition of the solution of nitrate of silver.

#### EXPERIMENT LXVI.

Add a grain or two of common salt, to half a test tube full of distilled water; and drop into the solution nitrate of silver; the mixture will instantly become turbid, and a dense white

precipitate will fall down, to the bottom of tube. Decant the supernatant fluid, and pour liquid ammonia upon the precipitate, which will immediately produce with it, a transparent solution, namely, nitrate of silver in ammonia. This is one of the characters which muriate of silver, is discriminated from muriate of lead; for the latter is not soluble in liquid ammonia.

## EXPERIMENT LXVII.

Prepare muriate of silver, in the manner directed; namely by decomposing a solution of common salt in water, with nitrate of silver; wash the muriate whilst still wet, with water, dry it on blotting paper, and keep it exposed to the light of day. Its beautiful white colour, will speedily be changed, and in a few hours it will have acquired a bluish black colour.

This change of colour is supposed to be owing to the partial reduction of the oxide of silver; from the light expelling a portion of

its oxygen. But there is reason to believe that it originates solely from a partial disengagement of a portion of the acid; because it is produced likewise by heat, for muriate of silver becomes blackened, before it enters into fusion, and a small quantity of muriatic acid, without any oxygen becomes disengaged. It likewise takes place by the action of air, independent of light; for muriate of silver exposed in an utter dark place, to a brisk current of air, becomes blackened; but not so speedily as in the rays of the sun.

## EXPERIMENT LXVIII.

When the quantity of muriatic acid in a fluid is extremely small indeed, no actual precipitate can be collected, but the solution which was limped before mixture, becomes more or less opalescent afterwards, as may be shown by dropping nitrate of silver into a decanter full of common spring, or river water, which will almost immediately, become more or less clouded or milky, according to the

quantity of muriatic acid which it contains, some combination or other, but no precipitate can be collected. In the analysis of mineral waters, this test saves much trouble the operator. If the water, for example, contains only muriate of potash, and of soda, other ingredients having been previously prepared, we have only to decompose them by nitrate of silver, and to dry the precipitate; 217.65 of muriate of silver indicate 100 of muriate of potash, and 235 of muriate of soda indicate 100 of common salt.

## EXPERIMENT LXIX.

Let five or six grains of sulphate of soda, (Glauber's salt), or Epsom salt, or alum, be dissolved in a test tube full of distilled water, and put half the mixture into another or second tube. Add to the contents of the first tube, a few drops of nitrate of silver. A considerable turbidness will take place; because the oxide of silver combines with the sulphuric acid of the sulphate, and forms with it, an in-

soluble compound salt, (sulphate of silver,) decant the supernatant fluid and transfer the precipitate, which has a pulverulent form, into a basin containing distilled water, which will speedily dissolve it when assisted by a gentle heat, but which is not the case with muriate of silver; which is perfectly insoluble in water.

#### EXPERIMENT LXX.

Add to the other half of the solution of sulphate of soda (Experiment LXIX.) nitrate of barytes, till no further cloudiness takes place, separate the precipitate, which is sulphate of barytes, by throwing the whole on a filtre, and assay, or test the fluid, which passes through the filtre, again with nitrate of silver, which now no longer will produce a precipitate, because the sulphuric acid has been removed by the nitrate of barytes.

#### EXPERIMENT LXXI.

Dissolve a few grains of sub-carbonate of potash, or of soda, in half a wine glass full of

distilled water, and add nitrate of silver to the solution. A white precipitate will fall down; namely carbonate of silver. But if a little pure nitric acid be added, this precipitate will become re-dissolved with an effervescence, which is not the case with muriate of silver.

#### EXPERIMENT LXXII.

Again add, a few grains of sub-carbonate of potash, or of soda, to half a wine glass full of distilled water, and drop into it so much nitric acid, as is sufficient to neutralize the subcarbonate of potash, which may be known by the solution not changing turmeric paper brown. (See page 35.) If into this fluid, nitrate of silver be dropped, it will not become turbid, and the effect of the carbonated alcali, is thus counteracted, by nitric acid. If a grain of common salt or any other combination of muriatic acid be added to the fluid, the nitrate of silver will immediately indicate the presence of muriatic acid, by a copious white curdy or flocculent precipitate.

## EXPERIMENT LXXIII.

The power of nitrate of silver is so great, that it will discover the minute quantity, of muriate of soda which constantly adheres to the skin, and is deposited there, from the perspirable matter of the living body. To shew this fact, put some distilled water with a few drops of nitrate of silver into a test tube, and shake it, closing the tube with the finger on the open end, applied as a stopper. The mixture after a few minutes shaking, will become perceptibly turbid, on account of having removed from the cuticle of the finger so minute a portion of muriate of soda, as defies the imagination, but the presence of which is thus rendered by the test obvious to the senses.

For the application of nitrate of silver as a test to detect minute portions of arsenic we are indebted to Mr. Hume, according to whose directions it is to be used in the solid state, or as fused sub-nitrate of silver, vulgarly called *lunar caustic*. The following process will illustrate its action.

## EXPERIMENT LXXIV.

Put two or three grains of arsenious acid, (white arsenic) and eight ounces of rain or distilled water, into a florence flask, heat the mixture over the lamp till the solution boils, and then add to it, a grain or two of sub-carbonate of potash or of soda. Pour a few table spoons full of the solution into a wine glass, and present to the mere surface of the liquid, a stick of dry sub-nitrate of silver. A yellow precipitate will instantly appear, which will proceed from the point of contact of the sub-nitrate with the fluid, and settle towards the bottom of the glass as a flocculent and copious precipitate. Dr. Marcelet has lately pointed out the following modification of this test.

## EXPERIMENT LXXV.

Let the fluid suspected to contain arsenic be filtered, and suffer the end of a glass rod, wetted with liquid ammonia to be brought into contact with it, and let the end of a glass rod

also wetted with the solution of nitrate of silver be immersed in the mixture, a yellow precipitate will appear at the point of contact, and will gradually fall down to the bottom. As this precipitate is soluble in ammonia, the greatest care is necessary not to add an excess of that alkali.

The objection arising from the action of muriatic acid, upon this test, when thus employed for arsenic, is easily obviated, for if a little muriatic acid be added to the fluid, suspected to contain arsenic, and the nitrate of silver very cautiously be added, till the precipitate ceases, the muriatic acid will be removed, and the arsenic remain in solution, and the addition of liquid ammonia will produce the yellow precipitate in its characteristic form.

#### EXPERIMENT LXXVI.

The effect of nitrate of silver, for detecting minute portions of sulphuretted hydrogen, may be shewn by immersing part of the white

of an egg coagulated by heat, into distilled water mixt with a small quantity of nitrate of silver, and suffering it to stand for about 24 hours. During this time the whole solution, as well as the albumen, will acquire a dark brown colour, because the albumen of the egg contains sulphur. The blackening of a silver spoon on touching it with the white of a boiled egg, also illustrates this fact.

#### EXPERIMENT LXXVII.

Put water impregnated with sulphuretted hydrogen gas, into a saucer or wine glass and hold over, and also close to the surface of the water, a slip of paper wetted with a solution of nitrate of silver. The sulphuretted hydrogen gas escaping from the fluid, will instantly cause the solution of silver to become blackened; the silver which it contains will re-appear in a metallic form, and being combined with sulphur, the whole assumes a brilliant metallic and iridescent colour.

## EXPERIMENT LXXVIII.

Write on paper with a dilute solution of nitrate of silver ; the writing will be invisible when dry, and kept defended from the light. But if the paper be immersed into water impregnated with sulphuretted hydrogen gas ; or if a feather or sponge dipped in this fluid be passed over it, the characters will instantly acquire a dark brown or black colour, the intensity of which is according to the strength of the nitrate of silver employed.

## XVIII. ACETATE OF SILVER.

This re-agent, the chemical action of which is in every respect similar, to nitrate of silver, is particularly well adapted for examining mixtures of nitrates and muriates, if we wish to ascertain and separate the muriate acid, without adding any additional quantity or extraneous nitric acid to the mixture, which would be the case if nitrate of silver be employed. We become thus also en-

bled to discriminate the alcali combined with the muriatic acid, more readily, by its appropriate tests, namely muriate of platina, &c. Or even without the usual tests for alkalies; namely, by simply evaporating to dryness the fluid from which the muriatic acid has been separated by means of the acetate of silver, and re-dissolving the dry mass in alcohol. If this solution, after being evaporated to dryness, affords a deliquescent salt, we have reason to believe that the base of the salt is potash; and if it effloresces and remains dry on exposure to the air, there is then reason to believe it to be soda; or, for example, when nitrate of potash accompanies sulphates and muriates without any other nitrate the sulphates being decomposed by acetate of barytes, and the muriates by acetate of silver. The fluid after filtration may be evaporated to dryness, and the residuum treated with alcohol, which dissolves the acetates and leaves the nitrate; the quantity of which may be easily estimated. If an alcali be present, it ought, of course, to be previously saturated with an

acid. Acetate of silver is decomposed by exposure to light. The bottle containing a solution of it, becomes covered within ; with a metallic coat of silver, and a black powder separates. It therefore must be kept in opake bottles, or in the dark.

#### XIX. SULPHATE OF SILVER.

The combination of silver with sulphuric acid, may occasionally be used with advantage, as a test for detecting muriatic acid; where nitrate of silver is not so applicable; because it is not affected, like nitrate of silver, by salts with a base of sulphuric acid, so that when sulphate of silver is employed, we are certain that the precipitate produced by this test, when no uncombined alcali or earth is in the solution, is produced by muriatic acid only.

This test is best kept in opake bottles, for light has an action upon it. The silver which it contains is in part reduced and falls down as a black powder.

**XX. PHOSPHATE OF SODA.**

This salt in combination with carbonate of ammonia is employed as a re-agent for separating magnesia. The process was first patented out by Wollaston, and is as follows. Pour a solution of neutral carbonate of ammonia, into the fluid suspected to contain magnesia. No magnesia becomes precipitated if no earth be present, because the carbonic acid of the carbonate of ammonia, is sufficient to keep it in solution. But on adding phosphate of soda, the magnesia is transferred to phosphoric acid, and with which, and the ammonia, it falls down, as an insoluble triple salt. It is essential that the solutions should be somewhat concentrated ; and that the carbonate of ammonia be neutral. Phosphate of soda, when deprived of its water of crystallization, is likewise employed as a flux for the glass-pipe ; it materially facilitates the fusion of earthy substances, and metallic oxides, and is a more manageable flux than phosphate

of soda and ammonia, which is frequently recommended for similar purposes.

#### EXPERIMENT LXXIX.

Add to a solution of sulphate of magnesia, a solution of carbonate of ammonia, in sufficient quantity to saturate the acid, no change will take place ; but if to this fluid, which now contains sulphate of ammonia, and carbonate of magnesia ; a cold and saturated solution of phosphate of soda be added, it immediately becomes turbid, and a white powder subsides which is a triple salt ; namely, phosphate of magnesia and ammonia.

100 grains of this salt, dried at a temperature of  $100^{\circ}$  contain 19 of magnesia ; about 6 of muriate of magnesia ; and 62 of desiccated, or double that quantity of crystallized sulphate of magnesia. If instead of drying the precipitate, at a gentle heat ; we calcine it, we may then reckon the calcined phosphate of magnesia to indicate in every 100

ains, 38.5 of magnesia or to be equivalent  
226 grains of the crystallized sulphate of  
nat earth.

#### EXPERIMENT LXXX.

Dissolve common magnesia of commerce  
(bicarbonate of magnesia) in muriatic acid  
and add to the solution, carbonate of ammonia,  
no change will take place; but if a strong  
solution of phosphate of soda be added to  
the fluid which contains the muriate of magnesia  
and carbonate of ammonia, the mixture  
becomes turbid, and phosphate of magnesia  
and ammonia is deposited.

#### XXI. LIME WATER.

This fluid is frequently employed for ascertaining the presence of carbonic acid, not combined with a base, or combined in excess, with which it produces a white pulverulent precipitate, which again disappears when an excess of the fluid containing the carbonic acid is added (page 101); because the excess of

the carbonic acid, re-dissolves the neutral carbonate, which produced the cloudiness. The transparency of the mixture is likewise restored, by muriatic or nitric acid. The action of lime water is therefore modified, according to the quantity of the substance upon which it is made to act. There is another object which requires to be considered with regard to this test, to avoid fallacious results, namely; the precipitation of salts with a base of magnesia or alumine, which, with lime water, also produce a white precipitate. And a cloudiness is further produced, when sulphates are made to act upon this test. But the precipitate occasioned by lime, may readily be discriminated, as will be stated presently. Lime-water is farther made use of, as a test for oxy-muriate of mercury, or corrosive sublimate, with which it produces according to the quantity added, either a yellow or a brick-dust coloured precipitate ; and occasionally also for detecting the presence of arsenic, with the solutions of which it forms a white precipitate, (arseniate of lime) which being scarcely more soluble

than sulphate of lime, sinks to the bottom in the form of minute crystals, and when laid on an ignited piece of charcoal diffuses the alliaceous odour, peculiar to arsenic.

Some chemists have endeavoured to estimate the quantity of carbonic acid when contained in a mineral water, by the admixture of lime-water, namely, by adding lime-water to the mineral-water, fresh from the fountain-head, and collecting, drying, and weighing the carbonate of lime thus produced. But this method is fallacious in most cases, for the lime-water also precipitates all the carbonate of lime held in solution by carbonic acid, and the carbonate of magnesia, and besides it decomposes other magnesian salts, and causes their earth to precipitate.

#### EXPERIMENT LXXXI.

Half fill a wine glass with fresh prepared lime-water, and blow through the water by means of a tobacco pipe, or quill, the air respired from the lungs. The lime-water will

by this operation be rendered turbid, because the carbonic acid gas expired from the lungs combines with the dissolved lime, and forms with it a neutral carbonate of lime, which being insoluble in water, becomes precipitated. The precipitate may be made to disappear by the admixture of muriatic or nitric acid.

#### EXPERIMENT LXXXII.

Half fill a test tube with water impregnated with carbonic acid gas, and add to it lime water, a white precipitate (carbonate of lime) will fall down, which again becomes dissolved by the admixture of a few drops of muriatic or nitric acid.

#### EXPERIMENT LXXXIII.

Fill a two ounce phial with carbonic acid gas, (for the method of obtaining this gazeous fluid, see index, carbonic acid) and add to it about a table spoonful of lime water, close the phial and shake it; the lime water will become milky, because a neutral carbonate of

lime is produced. Put the turbid mixture aside and again fill the phial with carbonic acid gas, and pour this mixture again into the phial filled a second time with the gas. The lime-water will now become perfectly transparent, if not, expose it for a third time to a fresh portion of carbonic acid gas. The transparency thus effected, is owing to the neutral carbonate of lime, having combined with an additional quantity or excess of carbonic acid gas: a new body or super-carbonate of lime being produced, which is soluble in water. We therefore see that if water holding carbonic acid gas in solution, be added in small quantity only, to lime-water, an instant milkyess ensues, and a precipitate of carbonate of lime is produced; but if an excess of the carbonated water be added, it becomes clear again. If the fluid be heated, or merely suffered to be exposed to the open air, the excess of carbonic acid gas flies off, and a neutral carbonate of lime is re-produced, which being insoluble falls down as a white precipitate.

Hence all pump or well waters holding in solution super-carbonate of lime, &c. become turbid by boiling, and a crust or *fur* as it is called, is deposited in tea kettles, and other vessels in which such waters are frequently boiled; the heat expels the excess of carbonic acid, which held the earthy carbonate in solution, and the neutral carbonate of lime is deposited. It is thus that nature dissolves calcareous masses, which have been collected and deposited by these waters. When the waters, by their exposure to the air, lose the quantity of carbonic acid which favoured the solution of the lime, deposits are formed, and thus originate calcareous incrustations found in caverns, springs, &c. When these waters suddenly lose the excess of carbonic acid which was essential to the solution of the lime, there is an irregular precipitation ; hence those tender calcareous cellular stones, and calcareous spongy *tuffs* : but if the evaporation of the carbonic acid takes place slowly, it produces crystallisations, such as *stalactites*, &c.

## EXPERIMENT LXXXIV.

To a few ounces of fresh prepared lime water, add two or three grains of subcarbonate of potash, the solution will become turbid and yield a white precipitate; because the carbonic acid, of the alkaline subcarbonate, unites with the lime, and forms with it, a subcarbonate of lime, which being insoluble falls to the bottom; add dilute muriatic, or nitric acid, and the precipitate will again become dissolved.

## EXPERIMENT LXXXV.

Dissolve five or six grains of sulphate of magnesia, (Epsom salt,) in half a wine glass full of distilled water, and pour a little fresh prepared lime water into the solution; it will become turbid, and a white pulverulent precipitate will gradually fall down to the bottom of the glass. Lime water therefore decomposes also the salts of magnesia.

## EXPERIMENT LXXXVI.

Mix five or six drops of a concentrated solution of corrosive sublimate, with half a test tube full of lime water, no brick dust or orange coloured precipitate will be produced, but a yellow precipitate will fall down; on adding gradually more of the solution of corrosive sublimate, the mixture will acquire an orange colour, and a precipitate of the same hue will be deposited.

## EXPERIMENT LXXXVII.

Let fall eight or ten drops of a solution of arsenious acid, into a wine glass containing about one table spoonful of distilled water; and fill the remainder of the glass with fresh prepared lime water. The mixture will become milky in a few minutes, and a white flocculent precipitate (arsenite of lime) will gradually collect at the bottom of the glass. If to the turbid liquid thus obtained, a few drops of acetic, or nitric acid be added, it will

become clear again, because the precipitate becomes completely redissolved; and the same result takes place, by a copious admixture of the solution of arsenious acid. If the precipitate (arsenite of lime) be dried, and placed on an ignited piece of charcoal, it yields an alliaceous odour, which is peculiar to arsenic.

Lime water does not keep, but is speedily rendered useless, on account of the carbonic acid gas which it attracts from the air, when the bottle containing it, is frequently opened. It may be readily prepared for immediate use in the following manner.

Take two ounces of fresh burnt quicklime, put it into a stone-ware vessel, and gradually sprinkle on it, so much distilled, or rain water, as is sufficient to slake the lime, and keep the vessel covered whilst the lime slakes and falls into powder. This being done pour on it a pint of distilled or rain water, and mix the lime thoroughly with the water by stirring. After the lime has subsided, repeat the stirring and agitation for several times successively during the space of 24 hours, and then pre-

serve the liquor, upon a part of the lime left undissolved, in a well corked bottle, and filtré or decant off the lime water, when wanted for use.

The proportion of water above stated to be used, is scarcely sufficient to dissolve one-tenth part of the lime; but lime being of little value, and seldom thoroughly good, a little waste of this material is of no importance, where the object is to obtain a saturated solution of it in water, quickly and easily.

The most convenient state for keeping lime fit for immediate use, is, to convert it into a *hydrate*, which may be done by sprinkling so much water on dry quicklime, as is just sufficient to cause the lime to fall into a perfectly dry powder. In this compound or *hydrate of lime*, the lime is to the water, as 23 to 8. It may safely be preserved in this state, in glass bottles; which cannot be done with quicklime in its perfect dry form, for in that state it almost constantly breaks the bottle, on account of its swelling, from the moisture which it attracts, when the bottle is occasionally opened.

## XXII. TAN.

This substance is employed for detecting animal gelatine, or jelly, with which it forms an elastic, adhesive mass, which soon dries in the open air, and becomes converted into a brittle resinous-like substance, which is insoluble in water, and capable of resisting a great number of chemical agents. It greatly resembles over-tanned leather. The power of tan as a test of gelatine is very great. Dr. Wostock found a copious and *immediate* precipitate, on adding a moderately strong infusion of tan to water containing only  $\frac{1}{1000}$  of isinglass, and a very considerable precipitate where the gelatine was only  $\frac{1}{2000}$ . An *immediate* precipitate with tan, may therefore be considered as a pretty certain indication of gelatine. To render this test accurate, it is necessary to attend to the circumstance, that tan likewise produces a precipitate with albumen. This, however, is much less evident; it does not take place *immediately*, but only after the mixture has stood for some time; and the

distinction between these bodies is likewise easily established by the use of other tests.

Dr. Bostock has also pointed out a very ingenious method of detecting and ascertaining the quantity of gelatine contained in an animal fluid. If oxy-muriate of mercury produces no precipitate (see oxy-muriate of mercury, p. 73) we may be certain of the absence of albumen. Then the infusion of tan being mixed with the liquid in such a proportion that the filtered fluid will neither precipitate infusion of tan, or the animal liquid under examination, a precipitate falls down composed of about two parts of tan and three parts gelatine. Hence this precipitate dried in a steam bath, and multiplied by 0.6 gives the weight of gelatine in the liquid examined, very nearly.

#### EXPERIMENT LXXXVIII.

Mix a small quantity of dissolved glue, or isinglass, with water, and drop into it, a solution of tan; a copious flocculent precipitate

will immediately fall down, consisting of tan and gelatine.

#### EXPERIMENT LXXXIX.

Dissolve a small quantity of portable soup, (which may be had at the confectioners) in boiling water, and add to it, a solution of tan; an abundant curdy precipitate will take place like in the preceding experiment. The same will be the case if tan be dropped into broth.

#### XXIII. NITRATE OF COBALT.

This salt, has of late been recommended, by Mr. Gahn, the celebrated German mineralogist, and discoverer of the metallic nature of manganese, as a test for readily discovering the presence of alumine, in mineral substances when submitted to the trial of the blowpipe assay. It is to be used in the following manner; put on the substance to be tried, a drop or less, of a concentrated solution, of nitrate of cobalt, and then expose it to the flame, of the blowpipe dart. If the mineral

contains alumine, in any notable quantity, and is not too much charged with iron, or other colouring metals, it will soon acquire a blue colour, more or less vivid and intense, according to the purity and abundance of the alumine which it contains.

The test may be applied to the hardest gems, or softest clays. When the mineral is a hard stone, it is only necessary to pulverise it well, and to drop on it, a minute portion of the test, and then to expose it to the action of the blowpipe dart, upon a piece of platina foil. The test, however, labours under one disadvantage, for the earth of zircon produces the same blue colour, but as the characters of zircon earth are exceedingly well marked, the application of a few additional tests, readily enables us to know to which of the earths the colour be owing.

#### EXPERIMENT XC.

Let fall a drop of a solution of nitrate of cobalt, upon a piece of common pipe-clay of

the size of a pea, and heat the mixture gradually, on a slip of platina foil, before the blowpipe flame; the clay will acquire a small blue colour.

## EXPERIMENT XCI.

Moisten a piece of quicklime, chalk, magnesia, or a minute portion of pulverized flint, with nitrate of cobalt, and expose the mixture to the heat of the blowpipe dart: these earths will not acquire a blue colour; the mere effect of the nitrate of cobalt will be, to impart to them before the blowpipe flame, a dull grey or black colour.

## EXPERIMENT XCII.

Again; take a piece of light yellow ochre, drop on it a minute quantity of nitrate of cobalt, and make it red hot by means of the blowpipe flame; this substance will acquire a dark blue, or purple colour; because ochre

is chiefly composed of alumine. The oxide of iron which it contains acquires a red colour when heated, and this, with the blue effected by alumine, produces the purple or violet tinge.

#### XXIV. SUPER-ACETATE OF LEAD.

This is another test which may be employed for detecting muriatic acid, and sulphuric acid, with both of which it occasions a white precipitate, namely muriate of lead, and sulphate of lead. The precipitate produced by muriatic acid, is soluble in dilute nitric, and acetic acid, (see page 55 & 57) but the precipitate produced by sulphuric acid is not. Its action upon muriatic acid is much inferior to nitrate of silver. It is also decomposed by alkalies and earthly carbonates; but this may be prevented by a previous admixture of nitric acid. Super-acetate of lead, (or more properly acetate of lead) may also be employed as a test, for phosphoric acid, with which it produces a white precipitate; even a solution of phosphate of lime

is completely decomposed by this salt, all the phosphoric acid is separated and by double decomposition a precipitate of phosphate of lead is produced which is readily known by the following characters. When heated by the blowpipe on a piece of charcoal, it melts easily into a pearl-white globule, which immediately on discontinuing the flame cools into a button of a polyhedral form; and if the flame be continued, the phosphoric acid is gradually decomposed, and burns off with a luminous vapour smelling of phosphorus, and at last a globule of pure lead is left. The precipitate or phosphate of lead when dried at a low red heat, contains 22.5 per cent of phosphoric acid. If sulphuric acid in any combination should happen to be present in the solution of phosphate of lime, it will also be decomposed by the super-acetate of lead, and the precipitate will therefore be a mixture of sulphate and phosphate of lead. These are separable by dilute nitric acid, which will dissolve the phosphate of lead, but not the sul-

phate. Super-acetate of lead is one of the most delicate tests for discovering minute portions of sulphuretted hydrogen gas, or sulphurets in general, with which it instantly forms a black precipitate. It has been recommended as a test for carbonic acid, but is seldom employed, for that purpose, for we have better tests for carbonic acids. It has also been used as a test for uncombined boracic acid, particularly in the analysis of mineral waters. In that case the uncombined alcalies and earths (if any be present) must be saturated with acetic acid. The sulphates if any are present, must be decomposed by acetate, or nitrate of barytes, and the muriates by acetate or nitrate of silver. The filtered liquor, if boracic acid be contained in the water, will continue to give a precipitate, which is soluble in nitric acid of the specific gravity 1.8, and this precipitate or borate of lead, may be decomposed by boiling with sulphuric acid ; which forms with it sulphate of lead, and the boracic acid is set at liberty.

The fluid containing the boracic acid, may then be evaporated to dryness, and digested in alcohol, which then takes up the boracic acid.

## EXPERIMENT XCIII.

Drop into a test tube, half filled with distilled water, a grain of common salt, or a drop of muriatic acid, and add to the solution a drop of super-acetate of lead; a white precipitate will immediately fall down, which is muriate of lead. This precipitate is again soluble with the assistance of heat in nitric or acetic acid, and also in a large quantity of boiling water (see page 56), 100 parts of the dried precipitate indicate 75 of metallic lead.

## EXPERIMENT XCIV.

Add to half a test tube full of distilled water, a grain or two, of sulphate of soda, or of sulphate of potash, and assay it by the admixture of super-acetate of lead; an abundant white precipitate will fall down which is sulphate of lead.

## EXPERIMENT XCV.

Repeat the same experiment with a single drop of sulphuric acid, added to a wine glass full of water ; and the same appearance as in Experiment XCIV, will take place ; 100 parts of the precipitate (sulphate of lead) after having been heated moderately to redness, indicate 71 of lead.

## EXPERIMENT XCVI.

Super-acetate of lead, is the test usually employed in commerce for detecting the genuineness of lemon juice. This article, which is largely imported in the liquid state, is not unfrequently adulterated with some strong and cheaper acid. The sulphuric acid is most to be suspected. It is detected in the following way ; put some of the juice in a glass, and add to it a solution of super-acetate of lead. This will produce a copious white sediment ; after which add a few drops of strong nitric acid. If the juice contained no sulphuric acid, the

white precipitate will be redissolved, and the liquor become again clear, the citrate of lead, and malate of lead of which a small portion will also be formed) being readily soluble in nitric acid, but if the lemon juice was mixed with sulphuric acid, the sulphate of lead will remain at the bottom. If this be collected, washed, and dried, the quantity of sulphuric acid may be estimated from the known proportions of this salt, as stated, page 116.

#### EXPERIMENT XCVII.

Dissolve a few grains of sub-carbonate of soda, or of potash, in a wine glass full of distilled water, and pour half the solution into another glass. Drop into one of the glasses, a little super-acetate of lead; a white precipitate (carbonate of lead) will immediately be formed. Add to the other glass, nitric acid, till the potash contained in the fluid is neutralized. This being done, pour into it also a few drops of super-acetate of lead, no precipitate will now appear, because the action

of the sub-carbonated alcali is thus counteracted, and the test will now indicate muriatic and sulphuric acid.

#### EXPERIMENT XCVIII.

Add to any quantity of water impregnated with sulphuretted hydrogen gas, a drop of super-acetate of lead ; clouds of a dark brown colour will immediately appear, and a precipitate of the same colour will be deposited, which is hydro-sulphuret of lead.

#### EXPERIMENT XCIX.

The effect of a sympathetic ink, with super-acetate of lead, may serve to shew in a striking manner the action of this test, with regard to sulphuretted hydrogen, namely ; by writing on paper with a pen, dipped in super-acetate of lead. No characters will be visible (if the writing has been made with a dilute solution of the re-agent). And if the paper be held over a saucer, or other vessel containing water impregnated with sulphuretted hydrogen gas, or when the paper is moistened with this

liquid the letters assume a brilliant metallic and iridescent colour.

#### EXPERIMENT C.

Dissolve two grains of phosphate of soda, in half a test tube full of distilled water, and drop into the solution, a little super-acetate of lead; a white precipitate will take place, which is phosphate of lead.—This precipitate disappears again by the admixture of nitric acid.

#### EXPERIMENT CI.

Affuse upon bone ash (bone burnt to whiteness) sulphuric acid; a partial decomposition will take place, because bone, which is phosphate of lime, gives up part of its lime to the sulphuric acid, and an acidulous phosphate of lime is produced. If into this fluid when diluted with water, a few drops of super-acetate of lead are suffered to fall, a white precipitate takes place, which consists of all the phosphoric acid united to oxide of

lead. The sulphuric acid also falls down, in combination with another portion of the oxide of lead, and forms sulphate of lead. These two precipitates may be separated by dilute nitric acid, which dissolves the phosphate, but does not touch the sulphate of lead.

#### EXPERIMENT CII.

Let fall into water impregnated with carbonic acid gas, two or three drops of super-acetate of lead; a white powder will fall down, which is carbonate of lead, (white lead of commerce). The same effect will take place if the air respiration from the lungs be blown by means of a quill, or glass tube, through a solution of super-acetate of lead. The carbonate of lead, is soluble in caustic potash; and by the action of the blow-pipe on charcoal the acid is driven off, and the lead is reduced to the metallic state.

Super-acetate of lead strongly attracts carbonic acid from the air, it ought therefore be kept in a well stopped bottle.

## XXV. SUB-ACETATE OF LEAD

This combination of lead with acetic acid, which is vulgarly called *Goulard's Extract*, is recommended by Dr. Bostock to discover the presence of *mucous*, or animal mucilage; and to discriminate it in the analysis of animal fluids, from gelatine, with which it has been so often confounded. Sub-acetate of lead instantly acts upon animal mucous, and produces with it a copious white and flaky precipitate, but it is not sensibly rendered turbid by a solution of animal gelatine. A solution of sub-acetate of lead, may also be employed for separating the extractive, acid, and colouring matter from wine, so as to enable us to abstract from the remaining colourless liquor, by means of a sub-carbonated alkali, all the water which it contains; and to ascertain in a ready manner the quantity of alcohol or brandy, which was present in the wine. And this method of obtaining alcohol or brandy from wine, at once destroys the commonly received opinion, first entertained be-

Fabrony, namely; that the spirit obtained from wine, be formed during the distillatory process, whilst on the contrary it clearly proves, that brandy or spirit of wine, exists ready formed in all vinous liquors, and that it may be separated from them, without distillation. And further: that the quantity thus separated, is precisely equal to the proportion yielded by the common method of distillation. The process which is as follows, was first pointed out by Mr. Brande.

#### EXPERIMENT CHI.

Add to eight parts by measure of the wine to be examined, one part, of a concentrated solution of sub-acetate of lead; a dense insoluble precipitate will ensue; it is a combination of the test with the colouring, extractive, and acid matter of the wine. Shake the mixture for a few minutes, pour the whole upon a filtre, and collect the filtered fluid. It contains the brandy or spirit, and water of the wine, together with a portion of the sub-acetate of lead, provided the latter has not been

added in excess; in which case a part (of course) remains undecomposed. Add in small quantities at a time, to this fluid; warm, dry and pure sub-carbonate of potash, (*not salt of tartar, or sub-carbonate of potash of commerce*) which previously has been freed from water by heat; till the last portion added, remains undissolved. The brandy or spirit, contained in the fluid, will thus become separated; for the sub-carbonate of potash abstracts from it, the whole of the water with which it was combined; the brandy or spirit of wine forming a distinct stratum, which floats upon the aqueous solution of the alkaline salt. If the experiment be made in a glass tube from one half an inch, to two inches in diameter, and graduated into 100 equal parts; the percentage of spirit in a given quantity of wine, may be read off by mere inspection.

By operating on artificial mixtures of alcohol and water, Mr. Brande, found that when the alcohol is not less than 16 per cent the quantity indicated by the dry, and warm subcarbonate of potash, after the colouring

and acid matter has been separated by sub-acetate of lead, was always within one half part in 100 of the real proportion, contained in the mixture.

*Table exhibiting a comparative view of the quantity of Alcohol, (specific gravity, 825,) obtained by Mr. Brande from various Wines and Spirituous Liquors.*

	Strongest.	Medium.	Weakest.
Rum .....		53.68	
Brandy ....		53.39	
Hollands ..		51.60	
Raisin wine		25.77	21.40
Port .....	25.83	23.49	19.34
Madeira ....	24.42	22.27	17.26
Marsala ....	25.87	21.56	
Currant wine		20.55	
Constantia ..		19.75	
Sherry ....	19.83	19.17	18.25
Lisbon ....		18.94	
Bucelias....		18.49	

*Table exhibiting a comparative view of the quantity of Alcohol, (specific gravity, 825,) obtained by Mr. Brande from various Wines and Spirituous Liquors.*

	Strongest.	Medium.	Weakest.
Red Madeira		18.40	
Cape muscat		18.25	
— madeira		18.11	
Grape wine		18.11	
Calcavella ..		18.10	
White hermitage .....		17.43	
Rousillon ..		17.26	
Malaga .....		17.26	
Malmsey mad.		16.40	
Sheruatz.....		15.52	
Syracuse ..		15.28	
Nice .....		14.63	
Claret.....	16.32	14.44	12 91
Tent .....		13.30	

*Table exhibiting a comparative view of the quantity of Alcohol, (specific gravity, 825) obtained by Mr. Brande from various Wines and Spirituous Liquors.*

	Strongest.	Medium.	Weakest.
Burgundy ..	14,53	13.24	11.95
White champ.		12.80	
Vin de Grave		12.80	
Fontignac ..		12.79	
Cote roi....		12.32	
Red hermitage		12.32	
Gooseberry wine ....		11.84	
Hock .....	14,37	11.62	8.88
Tockay ....		9.88	
Elder wine..		9.87	
Cyder.....		9.87	
Perry .....		9.87	
Ale.....		8.88	
Brown stout			8.80

The following Table exhibits the quantity of Alcohol contained in Ale, Porter, and other Kinds of Malt Liquors. See Repository of Arts, No. 2, p. 74, 1816.

Kind of Malt Liquor	Quantity of Alcohol.			
100 parts contained.	Parts of Alcohol.			
Ale, home-brewed	-	-	-	8.30
Ale, Burton, three samples yielded upon an average	-	-	-	6.25
Ale, common London-brewed, six samples yielded upon an average	5.			
Ale, Scotch two samples, ditto	-	5.75		
Porter, London, eight samples, ditto	4.			
Porter, bottled, three samples, ditto	-	2.75		
Brown stout, four samples, ditto	-	5.		
Small Beer, six samples, ditto	-	0.75		

## EXPERIMENT CIV.

The action of sub-acetate of lead as a test for mucous, may be shewn in the following manner. Rince and macerate, an oyster, in cold distilled water; evaporate to dryness the mucous matter thus obtained; re-dissolve the dry mass in distilled water and filtre it. If to this fluid, a few drops of sub-acetate of lead be added, a copious white flocculent precipitate will be obtained.

The same effect is produced if the solid matter obtained by evaporating saliva to dryness, be re-dissolved in water, filtered and submitted to the action of this test.

## XXVI. MURIATE OF PLATINA.

This is a valuable test for distinguishing the salts of potash, from those of soda, it produces with all the salts of potash, a yellow precipitate, which is not an oxide of platina, but a triple salt, (prussiate of platina and potash) and it does not effect the salts with a base of

soda. In using this test, it is essential that there be no excess of acid; and the solution should be somewhat concentrated. Its action is greater, than tartareous acid, (see page 58).

#### EXPERIMENT CV.

Add to half a test tube full of distilled water, a few grains of potash, or sub-carbonate of potash; and then add a drop of the solution of muriate of platina; the fluid will instantly become turbid, and a yellow precipitate will fall to the bottom of the tube.

#### EXPERIMENT CVI.

Add to a like quantity of distilled water, a few grains of soda, or of subcarbonate of soda, and add to it also muriate of platina; no change will take place, because soda is not precipitable by this test.

## EXPERIMENT CVII.

Drop into a concentrated solution of sulphate of potash, a little muriate of platina, the same phenomena will take place as in Experiment CVII.

## EXPERIMENT CVIII.

Add to a solution of sulphate of soda, a few drops of muriate of platina no change will take place.

In this manner the two alkalies, viz. potash and soda, and their combinations are easily discriminated. *See also Tartareous acid, page 58.*

## XXVII. GREEN SULPHATE OF IRON.

This salt, has been recommended for ascertaining the presence of oxygen gas, of which mineral, and other waters, some time contain a small quantity. The presence of this gas, is discovered by dissolving in the water a small quantity of this salt. If the water be entirely

free of oxygen, and the phial containing it being well stoppt, the solution is transparent ; but if otherwise, it soon becomes slightly turbid, from the oxide of iron attracting the oxygen of the water, and a small portion of it in this more highly oxidated state, leaving the acid becomes precipitated.

Green sulphate of iron is also employed for detecting the presence of gold, with which when in a state of solution it produces a brown precipitate, which is metallic gold, (see page 68). It also throws down palladium in a metallic form. It is likewise useful, for detecting gallic acid, with which, (like all other salts of iron) it produces a precipitate which speedily becomes black on exposure to the air.

#### EXPERIMENT CIX.

Fill a phial brim full with the water to be examined and drop into it a few crystals of sulphate of iron, and cork the bottle close. In a little time the sulphate of iron will be dis-

solved, and if the mixture be suffered to stand for six or eight hours, a brown oxide of iron or ochre precipitate will fall to the bottom, if oxygen gas was present in the water.

The action of this test must be received with some limitation; for common air which is present in all natural waters, produces in part, a like effect, and it is only from comparing the quantity of the precipitate with common spring water, that some notion may be formed. Mr. Henry expelled the air from a portion of spring water by boiling; 100 cubic inches of the water yielded 4.76 inches of gas. This gas he found a mixture of 3.35 inches of carbonic acid, and 1.33 of atmospherical air. It is to the presence of these two elastic fluids, that water owes its taste, and many of the good effects which it produces on animals and vegetables. Hence the vapidness of newly boiled water from which these gasses are expelled.

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## EXPERIMENT CX.

Add to half a test tube full of distilled water, a few drops of muriate of gold; no change will take place; but if sulphate of iron dissolved in water, be added, a brown precipitate will fall down, which is gold in a metallic state, (see page 69). This process has been recommended for obtaining pure gold. From the purplish colour which the precipitate possesses, there is however reason to believe, that it contains a portion of oxide, and according to Proust, both muriatic and nitric acid, dissolve a little of it, which must be regarded as a proof of this oxidized state.

## XXVIII. ARSENIOUS ACID.

A solution of arsenious acid in water, is of use for discovering the presence of sulphured hydrogen gas, and sulphurets in general, with which it produces a yellow precipitate; and with the salts of lead it produces a white

precipitate. It is occasionally used as a standard of comparison, to confirm or invalidate the action of other tests, when employed for the discovery of arsenic, particularly in cases where collateral circumstances render the phenomena of the usual tests doubtful.

#### EXPERIMENT CXI.

Add a little of the solution of arsenious acid to half a test tube full of distilled water, and no alteration of colour will take place; but on adding to the fluid, water impregnated with sulphuretted hydrogen gas, a bright yellow precipitate will be produced, which is hydro-sulphuret of arsenic.

#### XXIX. MURIATE OF GOLD.

It is chiefly of use for detecting the presence of tin, with the solutions of which, when the tin is at a *minimum* of oxidation, it produces a purple, or purplish brown precipitate; hence muriate of gold, and sub-muriate of

tin, are reciprocally tests for each other. See *Sub-muriate of tin*. Muriate of gold has also been recommended as a test for albumen ; it throws down a dense flocculent precipitate from a solution containing  $\frac{1}{1,000}$  part of this substance ; but oxy-muriate of mercury (see page 70) is a better test for detecting this substance, because it effects no change in solutions, containing jelly, or animal gelatine, and mucous, whereas muriate of gold appears to have a slight action on these bodies.

### XXX. SULPHATE OF COPPER

This salt may be employed for discovering arsenic, with which it produces a bright yellowish green precipitate, provided a very small quantity of a subcarbonated alkali has previously been added to the fluid in which the arsenic is suspected. Water impregnated with sulphurated hydrogen gas produces with this salt, a dark brown precipitate, which is a hydro-sulphuret of copper.

## EXPERIMENT CXII.

Add a small quantity of solution of arsenious acid, to half a wine glass full of distilled water, in which previously a grain of subcarbonate of potash has been dissolved; a green flocculent precipitate will instantly fall down. This substance after being dried and mixed with a little powdered charcoal, and put into a glass tube closed at the bottom, and lightly stopped at the top, and then heated slowly to redness, will yield a metallic sublimate, which will give the strong smell, peculiar to arsenic, and which condenses on the sides of the tube, and lines it with a brilliant metallic coating. The same strong smell, and dense white fumes will be given, merely by putting the dried precipitate on an ignited piece of charcoal.

To identify arsenic, when this is one of the tests employed for detecting it, Dr. Henry, advises (very properly) to perform at the time of making the experiment, similar comparative experiments, with what is actually known to be arsenic.

Because the proportions of sulphate of copper, and alcali employed, have considerable influence on the distinct exhibition of the effect. Those which answer best, are one of arsenic, three of subcarbonate of potash (or common salt of tartar), and five of sulphate of copper. For instance, if a solution of one grain of arsenic, and three grains of potash, in two drachms of water, are mingled with another solution, of five grains of sulphate of copper in the same quantity of water, the whole becomes converted into a beautiful grass green mixture, from which a copious precipitate of the same hue slowly subsides, leaving the super-natant liquor transparent and nearly colourless. When the same materials, except with the omission of the arsenic, are employed in a like manner, a delicate sky blue mixture results, so different from the former, as not to admit of the possibility of mistake. In this way one-twentieth of a grain of arsenic diffused through 10 grains of water afforded to Dr. Bostock, by the addition of sulphate of copper and potash, in proper proportions, a distinct yel-

lowish green precipitate. See *Edinburgh Medical and Surgical Journal*, v. 166. In employing this test, it is necessary to view the fluid by reflected, and not by transmitted light, and to perform the experiments by daylight. To render the effect more apparent a sheet of white paper may be placed behind the glass or test tube in which the mixed fluids are contained.

#### XXXI. MURIATE OF LIME.

Is of some use, as an auxiliary test, for discovering the presence of alkaline carbonates, all of which decompose this salt, and produce with it carbonate of lime. It is further useful in the analysis of vegetable substances for detecting the presence of oxalic, malic and tartareous acid, with which it produces a white crystalline precipitate, which is highly insoluble in water, but readily soluble in dilute nitric acid, and the precise nature of which may then, be farther examined with less diffi-

iculty, so as to discriminate which particular vegetable acid entered into its composition.

Dry muriate of lime is employed also to strengthen spirit of wine, because the affinity of alcohol for water is so strong that it cannot be entirely freed from it by simple distillation. And by muriate of lime this may readily be effected. For this purpose one part of muriate of lime rendered perfectly dry by having been exposed to a red heat, and powdered after it has become cold, is put into the retort or still, over this, three parts of highly rectified spirit are to be poured, and the mixture well agitated ; by distillation with a very gentle heat, about two-thirds of the spirit will then be obtained in the state of perfectly pure alcohol.

### XXXII. BENZOATE OF AMMONIA.

Benzoate of ammonia is an excellent test for separating iron from manganese when together in one solution ; it is necessary when

employed for this purpose, that the solution containing the two oxides, should be rendered previously neutral with accuracy, by the admixture of ammonia, or any other alcali; and then the benzoate of ammonia may be added, till no more precipitate falls down. This precipitate is benzoate of iron, for all the manganese remains in the solution.

It may however happen that after having precipitated the iron from the solution containing several kinds of earths and metallic oxides; that part of the benzoate added, exists in the solution in excess; in that case it ought to be destroyed by boiling the solution with some acid, to obviate any confusion which might happen to be produced by the benzoic acid, on the continuation of the analysis.

Benzoate of ammonia not only separates iron from manganese, but it will also detach this metal from all earthy salts, and from nickel, cobalt, zinc, and many other metals, none of which are precipitated by this test, when properly applied; that is to say if the following circumstances be attended to.

Let the solution of the iron which ought to be in the state of peroxide, be rendered perfectly neutral, by the admixture of ammonia, and dilute it considerably with distilled water. Then let fall into the fluid, drop by drop, the solution of Benzoate of ammonia, till no further precipitate appears.

Throw the mass on a filtre, wash the insoluble residue with cold water, and dry the precipitate at a temperature of  $212^{\circ}$ . The Benzoate of iron thus obtained, contains 25 per cent of red oxide of iron, and 75 of benzoic acid and water.

If the benzoate of iron be digested for about 112 hours in liquid ammonia, it becomes completely decomposed; the red oxide of iron falls down to the bottom of the vessel, and Benzoate of ammonia remains in solution. We are indebted to Berzelius for this test. Its utility must be obvious to all, who are employed in analytical labours; because the complete separation of manganese from iron, has hitherto been attended with peculiar difficulty.

XXXIII. WATER IMPREGNATED WITH  
SULPHURETTED HYDROGEN GAS,  
OR  
LIQUID SULPHURETTED HYDROGEN.

This fluid precipitates many of the genera of metals from their solutions in acids, and produces with most of them, dark coloured precipitates ; and as it effects none of the earths, with the exception of zircon and alumine, it gives us a very valuable agent in analysis. And besides this, some metals may at once be recognised by the colour of the precipitate which they afford with this fluid. For example : with zinc this test produces a white precipitate, with the salts of antimony a bright orange coloured one ; arsenic is precipitated yellow ; tin, chocolate brown ; gold, a dark purple ; platina, reddish brown or nearly black. The solutions of lead (page 118) silver (page 91), mercury, copper and bismuth are precipitated of a dark brown or black colour. The colours of the precipitates are however very

isable to variation, from the state of combination. And particularly, the degree of oxidizement of the metal in the solution, has a material influence on the colour of the precipitates. Most of the precipitates are compounds of sulphuretted hydrogen, with the metallic oxide ; or in some cases a decomposition, more or less complete takes place ; part of the hydrogen first unites with part, if not all, of the oxygen of the metallic oxide, and reduces it nearly to the metallic state, or to a state of *minimum* of oxidizement, and the remainder of the sulphur and hydrogen unite with the metal, and the whole is separated from the acid of the solution in the form of a coloured precipitate, which therefore is either a sulphuret, or a hydro-sulphuret, of the metal, according to circumstances. Sometimes too, a small portion of sulphuric acid is formed at the same time, which renders the play of affinities still more complex. Some of the metallic solutions afford no precipitate with sulphuretted hydrogen, or at least the precipitate is resolved by a slight excess of acid. The

metals which afford no precipitate, are those chiefly which have a great affinity for oxygen, and which decompose water; namely, iron, cobalt, nickel, manganese, uranium, titanium, and cerium. But some of these metallic solutions become more or less deeply coloured by this test. Thus if liquid sulphuretted hydrogen be added to a weak solution of red sulphate of iron, the metal becomes reduced immediately to the state of the green or less oxygenized sulphate, and no actual metallic compound falls down; but sulphur is merely precipitated.

#### EXPERIMENT CXIII.

Dissolve one or two grains of sulphate of zinc (white vitriol) in half a test tube full of distilled water, and add to the solution, liquid sulphuretted hydrogen. The zinc will become precipitated in the form of a *white* gelatinous sediment, which is a hydro-sulphuret of zinc.

## EXPERIMENT CXIV.

Dissolve a few grains of tartrite of antimony and potash (emetic tartar) in a test tube full of distilled water; and drop into the solution gradually, liquid sulphuretted hydrogen; a bright *orange* coloured precipitate will be obtained.

## EXPERIMENT CXV.

Mingle a small quantity of the solution of arsenious acid, with half a test tube full of distilled water, and add to the mixture, liquid sulphuretted hydrogen, a *yellow* precipitate will immediately be produced.

## EXPERIMENT CXVI.

Let fall a few drops of sub-muriate of tin, into half a wine glass full of distilled water; and add to the mixture, liquid sulphuretted hydrogen; a *chocolate brown* precipitate will be produced.

## EXPERIMENT CXVII.

Mix a few drops of muriate of gold, with half a test tube full of distilled water; and add to the mixture, liquid sulphuretted hydrogen; a dark *orange brown* precipitate will fall down, which is sulphuret of gold, and which is composed of 80.39 gold, and 19.61 sulphur. (*Thompson's Annals*, No. 2, 1813, p. 141.) When exposed to heat it gives up its sulphur, and the residue is metallic gold.

## EXPERIMENT CXVIII.

Add to half a test tube full of distilled water, from ten to twenty drops of muriate of platina; and drop into the mixture, liquid sulphuretted hydrogen; a *black* precipitate will take place; which becomes reddish brown, with an excess of the test. It is according to Berzelius a perfect sulphuret of platina.

## XXXIV. TINCTURE OF GALLS.

This is an excellent test for detecting the presence of iron. It produces with this metal, a violet, or black precipitate, whether the iron be held in solution by carbonic acid, or by any other acid. If the iron be dissolved in carbonic acid, as is often the case in mineral waters, the solution after having been concentrated by boiling, is no longer tinged of a violet or black colour; but if it be held in solution by any other acid, the test still continues to produce a black precipitate. When the quantity of iron is exceedingly small, as is in general the case in chalybeate waters, tincture of galls does not actually produce a sensible precipitate, but only a slight purple tinge. A neat way of applying this test in cases where the quantity of iron is very small, consists in suspending a slice of the gall-nut, by a silken string in the water to be examined. The iron in order to afford a purple or black precipitate with tincture of galls must be in the state of a red oxide, and if

oxidized in a less degree, the effect will not be instantaneous, but will only take place after leaving the mixture to stand some time in contact with the air. The black colour can however be also rendered apparent, even in solutions of iron, containing the metal in a lower state of oxidation, by causes which cannot change the state of oxidation, as by dilution with water, or by the addition of a little alcali; and the reason therefore of it not appearing when the solution contains the iron at a *minimum* of oxidation, is, that the oxide in that state is retained by a stronger attraction in combination with the acid, than when the oxidation is more perfect.

The action of this test is influenced by the presence of other bodies. For example; if alkalies and earthy carbonates are present, it then produces with iron, a violet colour. If neutral alkaline salts are present: the colour is deepened, or of a dark purple; the presence of sulphate of lime, renders the colour of the precipitate at first whitish, and afterwards black; and carbonate of lime, produces the

same effect.—A dark purple colour indicates other alkaline salts; purplish red denotes sulphuretted hydrogen. Mr. Phillips has shewn that carbonate of lime has a considerable effect on the production of colour by the action of tincture of galls on salts of iron. When the iron is in a low degree of oxidizement, it rather heightens the colour: while, when it is at the maximum of oxidizement, it diminishes it so much, that if the iron be present in very minute quantity, it may even not be capable of being detected by this test. He has thus been enabled to explain a fact before inexplicable, which had given rise to various opinions with regard to the hot waters of Bath, namely; that when taken immediately from the spring and while hot, they give indication of a small quantity of iron, by the test of effusion of galls, while, when they have cooled under exposure to the air, so that the iron becomes more oxidized, they appear, from the same test, to contain none, though no iron is deposited during the cooling.

Tincture of galls produces with the solu-

tions of osmium, a vivid blue colour. With the solution of tellurium it affords a yellow precipitate—with solutions of mercury an orange coloured precipitate. Silver is precipitated of a white colour—uranium, brown—but the colour of the precipitates of these metals is upon the whole exceedingly variable, according to the combination or state of existence of the metal, and its degree of oxidizement.

#### EXPERIMENT CXIX.

Impregnate a quantity of distilled water with carbonic acid gas, shake it up for a few minutes with a small quantity of iron filings, let the mixture stand for about 24 hours, and then decant, or filtre it. Take half a wine glass full of this chalybeate water, and add to it, a few drops of tincture of galls. The mixture will assume a violet colour, and a black precipitate will become deposited, composed of gallic acid, tan, and oxid of iron.

## EXPERIMENT CXX.

Take another portion of the same chalybeate water, concentrate it by boiling to about one half of its bulk, and when it is become cold, filtré it; a brown precipitate (carbonate of iron) will fall down. The remaining clear fluid will no longer be altered by tincture of gall, which shows that the iron was combined with an excess of carbonic acid, which held it dissolved in the water.

## EXPERIMENT CXXI.

Add to two or three ounces of distilled water, five or six drops of sulphuric acid, together with a small quantity of iron filings, shake the mixture for a few minutes, and let it stand till it is become perfectly clear, or it may be filtered after having stood 8 or 10 hours.

To one-half of this clear solution of iron, add a few drops of tincture of galls, a violet colour which speedily darkens, will immediately appear.

Boil the other half of the fluid, till it is concentrated to about one half of its original bulk ; a brown powder will separate from the solution during the process. When the fluid is cold, filter it, and examine it again by adding to it a few drops of tincture of galls ; which will still occasion a violet or black colour, because the iron is combined with a mineral acid. A minute quantity of sulphate of iron, dissolved in distilled water, will give the same results.

The black, or violet coloured precipitate which this test produces, with the solutions of iron, is a combination of oxid of iron, with the gallic acid and tan, contained in the tincture of galls. In order that the iron may produce immediately a black precipitate, it must be in the state of red oxide ; for the less oxidized iron does not form instantly a black precipitate with these bodies ; but the tendency of the oxide of iron in the green sulphate, to receive a larger proportion of oxygen into the combination, is however such, that it is difficult to prevent a black precipitate from

being obtained, a few moments exposure to the atmosphere, or the action of the oxygen even of the air contained in the upper part of the test tube, is sufficient to communicate a violet tint. The brown precipitate which is produced when a solution of green sulphate of iron is boiled, (Experiment CXXI) is owing to part of the protoxide of iron, passing to the state of per-oxide, and combining with a portion of acid, falls down in the form of a brown powder, which is a sulphate, of the per-oxide with *excess of base*, or a sub-sulphate of iron.

## EXPERIMENT CXXII.

The effects of a sympathetic ink may be obtained by writing on paper with a dilute solution of green sulphate of iron; when the writing is dry, no letters are visible; and if a feather, or sponge moistened with tincture of galls be passed over the paper, the writing will instantly become visible and assume a black colour.

## XXXV. SULPHATE OF COPPER AND AMMONIA.

This test which is of a very fine azure blue colour, may be applied for discovering arsenic when contained in a liquid. It produces with it, a yellowish green precipitate, which after being separated from the super-uantant fluid, dried, and put upon ignited coals, produces the peculiar garlic like odour, which is characteristic to arsenic, when in contact with red hot coals. The precipitate is not soluble in water, nor in a solution of arsenious acid, unless added largely in excess, but it is soluble in liquid ammonia, and in nitric and most other acids.

## EXPERIMENT CXXIII.

Into half a wine glass full of distilled water let fall a few drops of the solution of arsenious acid, and add to it a few drops of solution of sulphate of copper and ammonia; a yellowish, or pea green precipitate will ensue, which if collected, dried and laid on an ig-

united piece of charcoal, will diffuse the peculiar garlic like odour, which characterises arsenic when heated with combustible bodies.

#### EXPERIMENT CXXIV.

Divide the whole of the fluid together with the precipitate of Experiment CXXIII. into four parts, and add to one, a little distilled water only; to the second, a few drops of solution of arsenious acid; to the third, liquid ammonia, and to the fourth, acetic, nitric, or any other acid. On the addition of water, no alteration will be perceived any more than from the solution of arsenious acid; but if the latter be added in great quantity, the precipitate becomes redissolved; a few drops of liquid ammonia will also immediately dissolve the precipitate, and a blue transparent fluid will be obtained, and a little nitric acid added to the fourth part, will in a like manner dissolve the precipitate, and form with it a colourless solution.

## XXXVI. SUB-BORATE OF SODA

Or common borax when deprived by fusion, of its water of crystallisation, becomes (glass of borax) an excellent flux for all earthy substances and metallic oxids, and is employed as such in the blowpipe assays.

It likewise renders an essential service in the operation of analyzing argillaceous minerals ; these substances which are but feebly acted on when fused with alkalies, yield readily to glass of borax. Corundum, and the hardest gems may be subdued by fusion, by means of this salt.

## XXXVII. SUB-MURILATE OF TIN.

This is a delicate test for platina, with the solutions of which it produces an orange coloured precipitate. It is also used as a test for detecting gold, with the solutions of which it affords a purple coloured precipitate, well known by the name of *purple precipitate of Cassius*; and used to give a red colour to

porcelain and glass. Sub-muriate of tin has likewise been recommended as a test for detecting albumen which it precipitates from its solution, but less actively than corrosive sublimate (see page 69), for water containing  $\frac{1}{200}$  of albumen is not altered by this test immediately, but only after the mixture has been suffered to stand some hours. With the neutral salts of palladium, this test gives a dark brown precipitate, but if added to excess, the liquor remains transparent, and of a fine emerald green colour. It also produces a dark brown precipitate, with a solution of corrosive sublimate of mercury. It is absolutely essential that the test be fresh prepared ; or at least the tin which it contains, should be at a *minimum* of oxidation.

## EXPERIMENT CXXV.

Mix a drop of muriate of platina, with a wine glass full of distilled water, and add to the mixture, a drop or two, of sub-muriate of tin ; a dense orange coloured precipitate will fall down.

## EXPERIMENT CXXVI.

Add to a wine glass full of distilled water one drop of muriate of gold, and let fall into this fluid, a few drops of sub-muriate of tin; a purple coloured precipitate will be obtained, consisting of oxid of tin and gold.

The colour and quantity of the precipitate is extremely various, from circumstances not easily appreciated. Its production is owing to the strong attraction of the tin to oxigen, and the large quantity of that principle, with which it is disposed to combine. When the two solutions are mixed, the oxide of tin being at the minimum of oxidizement, attracts part, or the whole of the oxigen of the oxid of gold; the two oxides, thus brought to states of existence different from those in which they were present in the separate solutions, are no longer soluble, are precipitated in combination. This theory also points out the circumstances required to be attended to in the process, to obtain the precipitate uniform; the whole depends on having the solu-

tion of tin at the minimum of oxidizement, or as nearly so as possible; and hence it must be used newly prepared, as otherwise the tin passes to too highly an oxidated state, and the effect of the test is lost.

The colour of the precipitate approaches more to a violet, as the muriate of tin bears a larger proportion to that of gold, and the colour communicated by this precipitate to porcelain, has the same variable character. When the sub-muriate of tin is in excess, the precipitate is more of a rose colour. A violet coloured precipitate M. Oberkampf found to contain, 60 per cent of oxide of tin, and 40 of metallic gold, and a fine purple coloured precipitate, contained 20½ per cent of tin, and 79½ of gold. From the experiments of M. Duportal, it appears that the degree of dilution influences much the quantity of the precipitate; so that when a very weak solution of muriate of gold and muriate of tin, be employed, one part of gold will produce as much as 5½ parts of purple precipitate.

## EXPERIMENT CXXVII.

Let fall into a test tube half filled with distilled water, one drop of a solution of oxy-muriate of mercury ; and add to the mixture a drop of sub-muriate of tin, a dark brown precipitate will instantly be produced.

Sub-muriate of tin has a strong tendency to acquire a further proportion of oxigen ; it should therefore be preserved in a well stopped bottle.

## XXXVIII. LIQUID AMMONIA.

Caustic, or liquid ammonia, is chiefly employed in analytical experiments, for discovering copper and nickel, with the solutions of which, when added in excess, it produces a clear sapphire blue colour.

To discriminate to which of these metals the blue colour be owing, it is only necessary that the ammonial solution be saturated in excess with sulphuric or nitric acid, and then immersing into it, a slip, or bar of zinc ; this

metal will precipitate copper, if the colour be owing to that metal, but with nickel it produces no effect; a mud coloured precipitate indeed is not unfrequently deposited from a solution of common nickel, but this precipitate is for the most part arsenic, and iron, with which nickel purified in the usual way, always abounds; and when all the arsenic capable of precipitation by this method, has fallen down, no further digestion with zinc will produce the least effect. The solution of oxid of nickel in ammonia, is decomposed according to Mr. Phillips, by the addition of soda or potash; and he has pointed out this, as affording a certain and easy method of obtaining, what is otherwise very difficult, nickel free from cobalt; the oxide of the latter when dissolved in ammonia, being very slowly and sparingly precipitated by potash, while that of the former is precipitated immediately and largely. He ascribes these decompositions to the two alkalies combining, and thus weakening the affinity of either to the metallic oxid.

Liquid ammonia produces with zinc a white

precipitate, which again becomes dissolved by a more copious admixture of the test. Liquid ammonia renders great services to the practical analyst, by enabling him to discriminate, in many cases, saline compounds with a base of lime, from those of magnesia; because it precipitates the salts of magnesia *partially*, but not the salts of lime; at least the latter are not precipitated, when lime alone is present. Certain precautions are however necessary in the application of this substance; because, although magnesia cannot be precipitated entirely from any of its solutions by ammonia, yet, if alumine be present, its precipitation is complete. Thus, Chevenix found, that on adding an excess of ammonia, to a solution of muriate of magnesia, mixed with a large proportion of muriate of alumine, nothing remained in the solution but muriate of ammonia: the two earths were precipitated in combination, and the affinity of the alumine to the magnesia had so much aided the decomposition, as to render it complete; and this affinity between the two earths, was even suffi-

cient to resist the action which potash is capable of exerting on alumine. And further; if in the examination of a liquid (for instance a mineral water) containing carbonic acid, either in a free state, or combined with magnesia, liquid ammonia be employed, it will take part of the excess of the carbonic acid from the magnesia, and the carbonate of ammonia will then throw down carbonate of lime; and if salts of alumine be present, they will likewise be effected.

It is of the greatest importance to be aware of the remarkable property which this reagent possesses, of forming triple salts, either with earths of metallic oxides, as is the case when sulphate of magnesia, sulphate of lime, and sulphate of iron occur together. In such a case for example, the excess of acid (if any) must first be neutralized by ammonia; if succinate of ammonia be then added, the iron if in a high state of oxidation, will become precipitated, (see *succinate of ammonia*) and the earths remain untouched.

Or, the solution may be evaporated to dry-

ness, and then exposed to a dull red heat for at least one hour. By this means the sulphate of iron becomes decomposed, its oxide of iron is left behind, and the sulphate of lime will be rendered insoluble, whilst the sulphate of magnesia is not altered. If the mass be then digested in water, the sulphate of magnesia becomes dissolved.

If sulphate of iron, and sulphate of magnesia, are alone present in a fluid, the insoluble residue will of course be oxide of iron.

Sulphate of lime, and sulphate of magnesia may also be separated by the following methods : If the quantity of sulphate magnesia is comparatively small, with regard to the sulphate of lime, liquid ammonia, when added to the solution, will separate portion of the magnesia (but not all) and the sulphate of lime will not be acted on ; provided the mixture be kept for some hours in a well corked bottle, to prevent it from absorbing carbonic acid of the atmosphere. But as it is more commonly required to separate sulphate of lime, from a larger quantity of sulphate of mag-

mnesia, advantage may be taken of the very difficult solubility of the former, and the ready solubility of the latter. The mixed solutions therefore should be concentrated highly by evaporation ; when, after some hours repose, most of the sulphate of lime will separate alone, and may be removed. The solution may then be evaporated to dryness, and strongly heated, and next pulverised and digested with three or four times its weight of cold water, by which the whole of the sulphate of magnesia will be dissolved, and what little sulphate of lime may remain, after the first process, will be left untouched. The solution may then be boiled with sub-carbonate of potash, to decompose the carbonate of magnesia, and the latter, when washed, dried, and ignited in a strong red heat, will be magnesia.

Liquid ammonia may also be employed as an useful re-agent, to separate oxide of iron, from oxide of manganese ; for this fact we are indebted to Mr. Hatchett; his method is as follows : pour into the solution of the ini-

neral in muriatic acid, diluted with water, liquid ammonia, till the mixture slightly restores the blue colour of reddened litmus paper. The oxide of iron will thus be separated, and remain on the filtre upon which the liquor is thrown, and the oxide of manganese will pass through it, in a state of solution combined with muriatic acid. To obtain it from this solution, it is only necessary that the fluid be evaporated to dryness, and exposed to a red heat to expel the muriate of ammonia.

#### EXPERIMENT CXXVIII.

Add three or four drops of the solution of sulphate of copper, to half a test tube full of distilled water, no change will take place; but if a few drops of liquid ammonia be added, in excess, the mixture will assume a fine sapphire blue colour, and thus indicate the presence of copper. This experiment may be pleasingly varied in the following manner.

## EXPERIMENT CXXIX.

Write on paper with a solution of sulphate of copper, the characters or writing, will be of a green colour, (or when the solution is dilute, the letters will be invisible) and if the paper be held over the surface of liquid ammonia contained in a glass or saucer, the writing will assume a beautiful blue colour, which departs again on removing the paper near a fire, or by suffering it to be exposed to the open air for some time.

The presence of copper when contained in pickles, to which a beautiful green colour has been given, according to the directions of the most popular homicidal cookery books, by boiling them with half-pence, or allowing them to stand for 24 hours in copper or brass pans (*See English Housekeeper, by E. Raffald, p. 352, 354.*) may thus be detected. It is only necessary to mince the suspected pickles, and to pour liquid ammonia diluted with an equal bulk of water over them in a stopped phial, if the pickles, contain the mi-

nutest quantity of copper, the ammonia will assume a blue colour.

### EXPERIMENT CXXX

Dissolve a few grains of sulphate of zinc (white vitriol) in half a test tube full of distilled water, and add liquid ammonia to the solution drop by drop ; a gelatinous precipitate will be produced ; which disappears again by a more copious admixture of the test.

### EXPERIMENT CXXXI.

Dissolve five or six grains of sulphate of magnesia in half a test tube full of distilled water, and add to the solution, liquid ammonia ; part of the magnesia only will be precipitated, the rest, remains in solution, and by evaporating the super-natant fluid, a triple salt will be formed consisting of sulphuric acid, magnesia, and ammonia.

Liquid ammonia is known to be perfectly deprived of carbonic acid, or fit to be used as a test, when it gives no effervescence

with acids, no cloudiness on mixture with strong alcohol, and particularly when it does not alter the transparency of a solution of pure lime (calcareous spar, or Carrara marble) in nitrous, muriatic, or acetic acid. This last, which is a most delicate test, should be made in a well corked bottle, for though liquid ammonia will not precipitate lime, carbonated ammonia will do it very readily, and the alkali, if exposed to the air, will speedily absorb from it sufficient carbonic acid to render this test fallacious. Besides this, it should yield no precipitate with oxalic acid. If muriate of ammonia is accidentally mixed with the liquid ammonia in the process of distillation, the presence of the muriatic acid is thus detected: saturate part of the liquor with distilled vinegar, and add to it a few drops of nitrate of silver, a white precipitate will then indicate the muriatic acid, for nitrate of silver is not dissolved by pure acetate of ammonia.

## XXXIX. OXALATE OF AMMONIA.

This salt is the most delicate tests for lime, with which it produces a white insoluble precipitate; its power is very great. One grain of lime, may be detected by it, in 42,250 of water. It also occasions a cloudiness in fluids containing magnesia, but then, its action is comparatively very feeble. The precipitate when a small quantity of magnesia is present, does not take place *immediately*, but only after some hours standing, and besides this; the magnesia must be present in considerable quantity, whilst on the contrary, the minutest portion of lime, is immediately affected by this test.

If oxalate of ammonia occasions a white precipitate before, and not after, having boiled the fluid submitted to its action (for instance a mineral water) the lime is dissolved by an excess of carbonic acid, and if it continues to produce a precipitate in a liquid which has been concentrated by boiling, we then are convinced that the lime is combined with a

fixed acid. From the quantity of the precipitate produced, we are enabled to determine the quantity of lime which the substance contains. To render this test decisive, the following precautions are however necessary :

1. The mineral acids, if any be present, must be previously saturated with an alkali.
2. Barytes, and strontia, if present, must be previously removed by sulphuric acid.

The quantity of lime, contained in the precipitate, may be known, by first igniting it with access of air, which converts the oxalate into a carbonate of lime; and by expelling, from this last, the carbonic acid, by a red heat, in a covered crucible. According to Dr. Marcet, 117 grains of sulphate of lime give 100 of oxalate of lime, dried at 160 degrees Fahrenheit.

#### EXPERIMENT CXXXII

Impregnate a small quantity of distilled water with carbonic acid, and shake the water up, for some minutes with a small portion of

powdered white marble, or chalk; suffer it to stand for at least two days, and then filtrate it.

To one half of this solution add a few grains of oxalate of ammonia, the fluid will immediately become turbid, and after some time, a white powder (oxalate of lime) will fall to the bottom.

Boil the other half of the liquor over the lamp furnace, for a little while; during this process, the fluid will become turbid, and a white precipitate (carbonate of lime) will be deposited; and the liquid after having also been filtered when cold, will now no longer be rendered turbid by the test, because the carbonic acid which held the lime in solution by virtue of an excess of carbonic acid, being volatilized, the lime becomes precipitated in the form of carbonate of lime (see page 101).

#### EXPERIMENT CXXXIII.

Make a mixture composed of three ounces of distilled water, a few grains of powdered white marble, or chalk; and a few drops of

muriatic acid ; shake the mixture for five or six minutes, and suffer it to stand, till it is become perfectly clear. Pour off half a wine glass full of the fluid, and add to it a few grains of oxalate of ammonia, the solution will immediately become turbid, and oxalate of lime will be deposited in the form of a white powder.

Having concentrated by boiling another portion of the solution, examine it in a like manner with oxalate of ammonia : and it will also afford a white precipitate ; because the acid which holds the lime dissolved cannot be volatilized by heat.

#### EXPERIMENT CXXXIV.

Pour a few drops of a solution of oxalate of lime, into a test tube full of lime water, and the same phenomena will take place as in the preceding Experiment.

## EXPERIMENT CXXXV.

Pour a little oxalate of ammonia into a tumbler full of common spring water; the water will become milky, and a white precipitate will fall down, because spring or pump water, always contains a portion of lime, combined either, with sulphuric, or carbonic acid; or sometimes both sulphate and carbonate of lime are present.

## EXPERIMENT CXXXVI.

Dissolve one or two grains of sulphate of magnesia, in a test tube full of distilled water, and add to it, a few grains of oxalate of ammonia; the solution will not become turbid. This experiment shows that magnesia does not form a salt of so difficult a solution as lime does, with oxalic acid, and that consequently, the presence of magnesia, is no material obstacle to the detection of lime by means of this test. If again a few grains or more, of sulphate of magnesia are added to the before mentioned quantity of water, and if to this, several

grains of oxalate of ammonia are added, the solution even then does not become turbid, although it be suffered to stand for some days.

#### XL. PRUSSIATE OF POTASH.

This is one of the most important tests ever discovered, because it has the valuable property of forming a precipitate, with all metallic solutions ; except those of platina, gold, antimony, tellurium, iridium, rhodium and osmium ; and from the colour of the precipitate, the particular metal may in many cases be inferred, and its quantity ascertained by easy means. It is chiefly used for detecting iron. If this metal exists in a state of high oxidization, in any fluid, it produces with this test, a Prussian blue precipitate, and when in a low state of oxygenation, the precipitate is white, but even then it very rapidly assumes a blue colour on mere exposure to the air. Copper is precipitated brown, zinc and tin afford a white gelatinous precipitate, and cobalt a distinct olive green one. Bismuth

gives with it a yellow precipitate. It is not effected by any of the earths. It is a very useful test for the analysis of mineral waters. If a mineral water taken fresh from the spring, affords a blue precipitate with prussiate of potash, but not after having been concentrated by boiling, it may be inferred, that the iron is present in the water, in combination with carbonic acid. And if the test, continues to strike a blue colour with the boiled, or concentrated water, the acid which held the iron in solution, is a mineral acid; the nature of which may be readily discovered, by the appropriate tests for acids, namely; by the salts of barytes (page 191 192), or those of silver, (page 79).

It is stated by some authors, that alumine is also precipitated by prussiate of potash: such a statement is erroneous. The error has arisen from the application of an impure test; and many of the contradictory results of mineralogical analysis by different chemists, are probably to be ascribed to a similar cause; but with barytes this test produces a *crystalline salt*, and this peculiar character which the

test presents, was regarded as in some measure assimilating barytes with the metals, the solutions of which are so generally precipitated by this test. Meyer and Klaproth observed, however, that no such precipitation from the solutions of barytes takes place *immediately*, unless when the prussiate employed is contaminated with a sulphate, from which it is difficult to obtain it free. Dr. Henry has shewn, that although no *immediate* precipitate is formed, on the addition of prussiate of potash, to a barytic salt, when the prussiate is pure, yet in a few hours small crystals are deposited from the liquor, but these crystals consist of prussiate of barytes; which proves, that the salts have, in part at least, exchanged their principles: and this, as Guyton has remarked, is not peculiar to this earth; a similar exchange happens with the salts of other earths and alkalies. Dr. Henry observes, likewise that the same crystals are formed from barytic water added to the prussiate.

## EXPERIMENT CXXXVII.

To three or four ounces of distilled water impregnated with carbonic acid gas, or common seltzer water, add a few iron filings, or iron wire, and let it stand in a corked phial for three or four days, occasionally shaking the mixture, and then filtré the solution, which will be an artificial chalybeate aerated water. To one half of it, add a grain or two, of prussiate of potash; the liquid will become blue, and some time after a blue precipitate will be deposited.

## EXPERIMENT CXXXVIII.

Evaporate the other half of the chalybeate aerated water, obtained in Experiment CXXXVII. to one half of its bulk, a brown powder, or sub-carbonate of iron will fall down. When the water has become cold, filtré it, and assay it again with prussiate of potash, which will now produce no effect; because the excess of carbonic acid, which held the iron in solution, is volatilized, and the iron thus reduced

to a subcarbonate of iron, is no longer soluble in the water.

## EXPERIMENT CXXXIX.

Shake two or three ounces of distilled water, with thirty or forty grains of iron filings, and five or six drops of sulphuric acid, for a few minutes ; let the mixture stand for a day or two, and decant or filter it, (or dissolve a few grains of sulphate of iron in half a wine glass full of distilled water :) to one half of this clear solution, add a few drops of a solution of prussiate of potash, and a blue precipitate will be formed.

If the other half of the fluid be evaporated a little and the same test be added to it, a blue precipitate will nevertheless be produced ; because the iron is held in solution by a mineral or fixed acid, which cannot be volatilized by heat.

## EXPERIMENT CXL.

Put into one wine glass half filled with distilled water, a few grains of prussiate of

potash, and into another glass, containing a like quantity of distilled water, dissolve a grain of green sulphate of iron; pour the solutions together when the salts are dissolved, and an olive green precipitate will be produced, which will speedily acquire a blue colour.

The effect of a sympathetic ink may be obtained by means of this re-agent, namely: writings made on paper with a dilute solution of sulphate of iron when dry, are invisible; but by passing a feather or sponge wetted with a solution of prussiate of potash, over the characters, the letters will become visible and appear of a blue colour. The Experiment may be reversed, by writing with prussiate of potash, and rendering the characters visible by sulphate of iron.

#### EXPERIMENT CXLI

Dissolve about one drachm of green sulphate of iron, in two ounces of water, add to the solution one or two drachms of clean (not

rusty) iron filings, boil the mixture briskly for about five minutes, and filter the fluid. Add a drop of this solution to a test tube full of water, and let fall into the liquor also, a few drops of a solution of prussiate of potash, and then cork the tube immediately. A copious white precipitate will fall down, which is white prussiate of iron, and which soon becomes green, but if the tube remains corked the white colour does not deepen, nor alter by exposure to light.

The iron in this solution is at a *minimum* of oxidisement; by being digested with metallic iron, it yields therefore a white precipitate with prussiate of potash.

#### EXPERIMENT CXLII.

Add a few drops of nitric acid, to the solution of sulphate of iron prepared in Experiment CXLI, and again test it with prussiate of potash; it will now produce prussian blue, because the iron having received oxygen

from the nitric acid, and being higher oxidated yields a blue precipitate with this test.

#### EXPERIMENT CXLIII.

Dissolve a grain of prussiate of potash in half a test tube full of distilled water, and add to the solution a drop or two of a solution of sulphate of copper : a *brown* precipitate (prussiate of copper) will immediately be produced

#### EXPERIMENT CXLIV.

Put a grain of sulphate of zinc (white vitriol) into a test tube full of distilled water, and add to the solution, a few drops of prussiate of potash, a gelatinous white precipitate, (prussiate of zinc) will fall to the bottom—which *again becomes dissolved* by the addition of liquid ammonia.

#### EXPERIMENT CXLV.

Add a few drops of the solution of submuriate of tin, to a test tube full of distilled

water, and let fall into the mixture a few drops of prussiate of potash, a very dense *white* gelatinous precipitate (like in Experiment CXLV.) will be produced; which does *not* become redissolved by the addition of liquid ammonia; it is prussiate of tin.

## EXPERIMENT CXLVI.

Let fall a few drops of the solution of nitrate of cobalt into half a wine glass full of distilled water, and add prussiate of potash to the mixture; a pale *olive green* precipitate (prussiate of cobalt) will be produced.

## EXPERIMENT CXLVII.

Add to half a test tube full of distilled water, two or three drops of a solution of muriate of bismuth, previously mixed with a little muriatic acid, (to prevent the muriate of bismuth from being decomposed by the water) and drop into the mixture prussiate of potash; a sulphur *yellow* precipitate, or prussiate of bismuth, will be produced.

## EXPERIMENT CXLVIII.

Let three test tubes be half filled with distilled water, put into the first, a drop or two of muriate of platina ; into the second, put a like quantity of muriate of gold ; and into the third a solution of super-tartrite of potash and antimony. If to either of these solutions, prussiate of potash be added, no change will take place, because the metals which form the bases of these salts, are some of those which are not precipitable by this re-agent.

## EXPERIMENT CXLIX.

Arrange three separate wine glasses, half filled with distilled water, pour a few drops of a solution of sulphate of magnesia into the first glass, add muriate of lime to the second, and a solution of alum to the third glass. If prussiate of potash be added to these solutions, no change will take place, because none of the earth contained in these salts, are precipitable by prussiate of potash.

In using prussiate of potash for detecting the quantity of iron in a fluid, when no other metal is present, requires considerable caution, to attain accurate results. The prussiate should on all occasions be previously crystallized, and the quantity of oxide of iron essential to its constitution, or at least an invariable accompaniment, should be previously ascertained; which may be done in the following manner: expose a known weight of the crystallized salt, to a low red heat in a silver crucible, by which means the prussic acid becomes destroyed, and the potash and oxide of iron is left behind; wash off the soluble part with distilled water; collect the rest on a filtre; dry it, and again calcine it with a little wax, and let it be again weighed: the result shews the proportion of oxide of iron contained in the salt. This varies from 22 to 30 *per cent*; when the quantity of iron is greater, the test is unfit for use, because it deposits Prussian blue, by the contact of acids. When the test is therefore employed for discovering the quantity of iron contained in any liquid, let a

known weight of the salt be dissolved in a given quantity of water; add the solution gradually, and observe how much is expended in effecting the precipitation, and before collecting the precipitate, warm the liquid, which generally throws down a further portion of Prussian blue. Let the whole be washed and dried, and then ignite the residue with wax. From the weight of the oxide, thus obtained, deduct the quantity of iron which, by the former experiment, is known to belong to the prussiate which has been added; and the remainder denotes the quantity of oxide of iron present in the liquor under examination.

On account, however, of the great difficulty of preparing this test, with a constant or uniform portion of iron, it is seldom employed, (but it certainly may) for ascertaining the *quantity* of iron in solutions; but only its presence.

Prussiate of potash when in solution and kept exposed to the light for some time, becomes partly decomposed, and hence it should be preserved in an opaque bottle. It is difficult to explain this change.

## XLI. PRUSSIATE OF AMMONIA.

This re-agent is of use only in the analysis of saline substances. It may happen for example, that a fluid contains neutral salts with alkaline bases, together with metallic salts. In this case, prussiate of potash cannot be well applied to separate the metallic salts, because it then would be difficult to ascertain whether the alkaline salts were originally present in the solution, or not. But if prussiate of ammonia be employed, no ambiguity can result. For the metallic salts, need only be precipitated by this test, and the earths, by carbonate of ammonia, in a temperature of  $180^{\circ}$  or upwards, in order to ensure the decomposition of magnesian salts, which this carbonate does not effect in the cold. The liquor may then be separated by filtration, and boiled to dryness, and the dry mass exposed to such a heat, as is sufficient to expel the ammoniacal salts. This application of heat will drive off, also, any excess of the ammoniacal carbonate, which might have retained

in solution either yttria, glucine, or zircon. The alkaline salts may be separated from these earths, by boiling the mixture in water, and filtering, and evaporating it. The salts with bases of fixed alkalies will remain unvolatilized. By this process, indeed, it will be impossible to ascertain whether ammoniacal salts were originally present; but this may be easily learned, by adding to the salt under examination, before its solution in water, potash; which, if ammonia be contained in the salt, will produce the peculiar smell of that alkali.

#### XLI. PRUSSIATE OF MERCURY.

This combination of prussic acid, with mercury, is a delicate test for palladium, which it separates in the form of a yellowish white precipitate (prussiate of palladium) from all its solutions—the solution of palladium, should be neutral. The precipitate thus formed, has the property of detonating when heated. The noise is similar to that occasi-

oned by firing an equal quantity of gunpowder, and accordingly the explosion is attended with no marks of violence unless occasioned by close confinement. The heat requisite for the purpose, is barely sufficient to melt bis muth, and the light produced is feeble, and can be seen only in the absence of all other light. By means of this re-agent, Dr. Wollaston has pointed out a method of obtaining palladium with facility from the ore of platina. The process is as follows: let any quantity of platina of commerce be dissolved in a sufficient quantity of nitro-muriatic acid, and free the solution as much as possible of its excess of acid (if it contains any) by evaporation, or by the addition of an alcali. This being done, mingle the solution with prussiate of mercury, until no farther cloudiness ensues, taking care to leave the mixture to stand for some minutes. The yellowish-white precipitate, which is then deposited, is prussiate of palladium. To obtain the palladium in a pure state, let the precipitate be heated to redness, and palladium will be obtained in a state of

purity, amounting to about four or five tenths, *per cent.* upon the quantity of the ore of platina employed. It is no matter whether the solution of the ore of platina has been rendered neutral by evaporation of the redundant acid, or saturated by the admixture of potash, of soda, or ammonia, by lime or magnesia, by mercury, by copper or by iron; or whether the platina has, or has not been precipitated from the solution by muriate of ammonia. The prussiate of mercury acts equally well in either case: for prussiate of mercury Dr. Wollaston found peculiarly adapted to precipitate palladium, exclusively of all other metals, on account of the great affinity of mercury for the prussic acid, which in this case prevents the precipitation of iron or copper. The decomposition of muriate of palladium by prussiate of mercury, Dr. Wollaston observes, is not effected solely by the superior affinity of mercury for muriatic acid, but is assisted also by the greater affinity of prussic acid for palladium; for he observed that prussiate of palladium may be formed by boiling

oxid of palladium in a solution of prussiate of mercury.

### XLIII. BARYTIC WATER

Is a very effectual test for detecting the presence of free, or combined carbonic acid, with which it forms a precipitate, which is soluble with effervescence in dilute nitric or muriatic acid; it is also a most sensible test of sulphuric acid, and all its combinations, which it indicates by a precipitate which is not soluble in water nor in dilute muriatic or nitric acid.

Barytic water may likewise be employed for separating strontia from barytes; this operation is founded on the stronger affinity of barytes, than of the former earth for acids. Hence if barytes and strontia be present in the same solution; barytic water may be added till no further precipitate falls down; the barytes seizes the acid, and the strontia becomes precipitated. The solution of strontia should have no excess of acid, which

would prevent the action of the barytic earth.

#### EXPERIMENT CL.

Drop barytic water, into water impregnated with carbonic acid gas, a copious white precipitate, which is carbonate of barytes, will fall down. Add nitric or muriatic acid to the mixture, and the precipitate will become redissolved.

#### EXPERIMENT CLI.

Blow the air respiration from the lungs, through barytic water, by means of a quill or glass tube, a white precipitate (carbonate of barytes) will fall down, originating from the carbonic acid gas contained in the air respiration from the lungs. See page 12 and 100.

#### EXPERIMENT CLII.

Pour some barytic water from one glass vessel into another repeatedly; it will speedily become turbid, and a white precipitate will fall

down; this shews that carbonic acid gas is contained in the atmosphere, which combining with the dissolved barytes, forms carbonate of barytes. Hence also if barytic water be left exposed to the common air, it will soon be covered with a thin white pellicle; which, when broken, will fall to the bottom of the vessel, and be succeeded by another, and this may be continued, till the whole of the barytes is separated from the water.

#### EXPERIMENT CLIII.

Let fall a single drop of sulphuric acid, into a tumbler full of distilled water, no alteration will follow, but if a little barytic water be added, a white precipitate, or sulphate of barytes will immediately be produced, which is not soluble in any dilute acid.

#### EXPERIMENT CLIV.

Drop barytic water into a decanter full of common spring or pump water, an immediate

cloudiness will ensue, and a white precipitate will gradually fall down, which likewise does not disappear again, (Experiment CLVI,) by the admixture of dilute muriate or nitric acid; because spring or well waters, always contain a minute quantity of sulphate of lime, or other salts containing sulphuric acid; and this acid joins the barytes, and produces the white insoluble precipitate, or sulphate of barytes.

#### EXPERIMENT CLV.

To a solution of a few grains of sub-carbonate of potash, or of soda in half a wine glass full of distilled water, add barytic water; which will immediately produce a turbidness; because the barytes separates the carbonic acid from the subcarbonated alcali, and falls down with it in the state of a carbonate of barytes. By adding a sufficient quantity of the solution of barytes the whole of the carbonic acid may thus be taken away from a carbonated alcali, and the alcali remains perfectly pure, or at least free from carbonic and sulphuric acid

This re-agent may also be employed for purifying rain water, so as to render it fit for chemical researches. Rain water collected from the roofs of houses, not the first water which is directly received from the gutters, at the commencement of a shower, but that which descends after the rain has sufficiently washed the surface of the tiles, contains seldom any other impurities, than a minute portion of sulphate of lime, and a small quantity of earthy matter mechanically suspended. The latter may be moved by immediate filtration, and the former, by carefully adding to it, barytic water. This will remove the sulphuric acid, and fall down with it as an insoluble precipitate ; the lime which remains partly dissolved, afterwards likewise falls down by absorbing carbonic acid gas, from the atmosphere, or it may be precipitated by adding to the water, a portion of water impregnated with carbonic acid gas, and which will also destroy any excess of barytic water, if part should have been added in excess. In this manner the water necessary for chemical experiments may be economically

supplied without much trouble and almost at no expense.

Barytic water soon spoils by the frequent opening of the bottle containing it, but it may be readily prepared, by dissolving a small quantity of barytic earth, or hydrate of barytes in distilled water.

#### XLIV. MURIATE OF BARYTES.

This salt is extremely well adapted for discovering the presence of sulphuric acid, either when in a disengaged state, or when combined with other substances. It produces with sulphuric acid (like barytic water) a white precipitate, which requires for its solution 43,000 times its weight of water, and which is also perfectly insoluble in all acids, except the most concentrated; hence the precipitate obtained by this test, may be collected, washed, and dried with the greatest facility, and without risk of loss; it is free from smell and taste, and undergoes no change by being heated red hot, without addition, except the loss of water which it may contain. In a

very strong fire or before the blow-pipe flame, it melts into an opake milky globule. From the quantity of the precipitate produced by this re-agent, we may learn the quantity of sulphuric acid, which the test has separated from the solution, for 100 parts of the precipitate after being calcined, contain very nearly two-thirds of barytes, and one-third of acid., or 66.6 per cent. of the former, and 33.3 of the latter. Dr. Wollaston assumes 66 parts of barytes, and 34 of sulphuric acid ; Berzelius, 65.69 of barytes, and 34.31 of acid. This test which forms one of the most important instruments in analysis, is also decomposed (like barytic water) by carbonated alkalies; but the precipitate is then soluble in dilute muriatic or nitric acid; and may be prevented, by adding to the solution to be assayed, a few drops of muriatic acid. Or if any excess of alcali has produced a precipitate of carbonate and sulphate of barytes, the two precipitates may easily be separated by mere digestion in dilute muriatic acid, which removes the carbonate of barytes and does not touch the sulphate..

Concentrated nitric acid, also decomposes a concentrated solution of muriate of barytes, the precipitate is crystallized nitrate of barytes ; this is owing to the more sparing solubility of the nitrate, than of the muriate of barytes in water. Hence in this case the precipitate is soluble in water, by which it may be easily distinguished from sulphate and carbonate of barytes. This decomposition of muriate of barytes, was first noticed by Mr Huine. It may serve to guard the young chemist against drawing false conclusions, particularly with regard to the examination of the purity of nitric acid, when examined by means of this test.

#### EXPERIMENT CLVI.

Fill two test tubes with distilled water, and let fall into one of them, a drop of sulphuric acid, and into the other, a few drops of muriate of barytes ; no change will take place in either of them ; but if only a little of the fluid containing the muriate of barytes, be poured into the liquid containing the sulphuric acid, a

copious white precipitate (sulphate of barytes) will take place, which will not become redissolved by the admixture of dilute muriatic or nitric acid.

#### EXPERIMENT CLVII.

Put a grain of sulphate of soda (glauber's salt) into half a wine glass full of distilled water, and when dissolved, add to the solution, a few drops of muriate of barytes. The same appearance will be perceived as in Experiment CLVI.

A like effect will take place if the liquid holds alum, epsom salt, white vitriol or any other sulphate in solution.

#### EXPERIMENT CLVIII.

Dissolve a few grains of subcarbonate of potash, in a wine glass full of distilled water, and pour half the solution into another glass. Drop into one of the glasses, a little muriate of barytes, a white precipitate will fall down (carbonate of barytes) which again disappears by the admixture of pure dilute muriatic, or

nitric acid. Drop into the other glass pure nitric or muriatic acid, in sufficient quantity to saturate the subcarbonate of potash which it contains, and then add to the mixture also muriate of barytes, which now will produce a precipitate, which is perfectly insoluble in muriatic and nitric acid, because the free alcali being neutralized by the nitric acid, the precipitate produced by the test, can only be occasioned by the presence of sulphuric acid

#### XLV. ACETATE OF BARYTES.

This salt of barytes, the action of which as a test is similar to the preceding re-agent, is particularly well adapted for ascertaining the presence of sulphuric acid, when contained in vinegar, and in sulphureous acid. And although it may produce a white precipitate with genuine vinegar, on account of the malic, citric, or tartaric acid which this fluid may contain, either in a free state, or combined with an alkaline base, but the precipitate then produced may be discriminated

from the precipitate produced by sulphuric acid, by merely exposing it to heat, in order to destroy the vegetable acid, so as to convert it into a sub-carbonated alcali. This being done, the residue will dissolve and effervesce with dilute acids. Whereas the precipitate produced by sulphuric acid when similarly treated, remains virtually insoluble in dilute acids. This test may likewise be employed with advantage, for readily ascertaining both the nature, and quantity, of alkalies and alkaline sulphates in fluids, when no other sulphates are present, in the manner to be stated presently.

#### EXPERIMENT CLIX.

Add to vinegar a few drops of acetate of barytes, a copious white precipitate will fall down; collect this precipitate, dry it, and expose it to the heat of the blowpipe flame on a slip of platina foil, till all the carbonaceous matter is burnt away, and the product has assumed a white, or gray colour. Transfer the mass which is chiefly subcarbonate of potash, into a test tube, and pour upon it dilute mu-

riatic or nitric acid, which will instantly dissolve it with an effervescence, which therefore shows, that the vinegar was free from sulphuric acid.

#### EXPERIMENT CLX.

Repeat the same experiment with a portion of vinegar, to which a drop of sulphuric acid has been added. The precipitate obtained in this case, which is sulphate of barytes, after having been treated in the same manner with the blowpipe flame, will not be soluble in any dilute acid.

#### EXPERIMENT CLXI.

Dissolve a little sulphate of soda, or sulphate of potash, in distilled water, and pour into the solution, acetate of barytes, a precipitate will take place, (which is sulphate of barytes) decant the supernatant fluid, evaporate it to dryness, and digest the residuum in alcohol ; it will dissolve. Evaporate the solution to dryness again, and the dry salt, will deliquesce if it be acetate of potash, but efflo-

resce, if it be acetate of soda ; 176 grains of ignited sulphate of barytes indicate 100 grains of dried sulphate of soda : while 136.36 grains of sulphate of barytes indicate 100 of dry sulphate of potash. The two alkalies, viz. potash and soda may thus be diserminated. See also muriate of platina, p. 123, and tartareous acid, p. 58.

#### XLVI. NITRATE OF BARYTES.

This is another salt of barytes, which acts in every respect like the combination of barytes with muriatic acid. Instances however frequently occur in analytical operations, where the introduction of muriatic acid into the compound, would render the analysis embarrassing, and in such cases, nitrate of barytes is employed more successfully. It is of particular use also, to discover the alkalies, namely potash or soda, when in fossils, and to ascertain their quantities. See *Manual of Analytical Mineralogy intended to facilitate the Analysis of minerals, by F. Accum, Vol. II. p. 365.*

**XLVII. MURIATE OF ALUMINE.**

This test has been recommended by Mr. Kirwan, as indicative of carbonate of magnesia, when present in mineral waters, and which cannot, like carbonate of lime, be totally separated by ebullition, but remains, till the whole liquid is evaporated. By adding muriate of alumine to the boiled water, a precipitate of carbonate of alumine is thrown down, if carbonate of magnesia be present, but not otherwise, unless there be an excess of alkali, which may easily be neutralized by an acid.

**XLVIII. SUCCINATE OF AMMONIA.**

This test is recommended by Klaproth as an useful re-agent for detecting iron, and for readily ascertaining its quantity when in a solution; the iron however must be in the highest state of oxidation, and in applying this test, it is necessary not to use more than is exactly sufficient for the purpose, because an excess is liable to re-act on the precipitate.

It produces with iron a brown precipitate. It is very useful to separate oxide of iron, from oxide of manganese.

#### EXPERIMENT CLXII.

Put a few grains of green sulphate of iron, into a test tube, pour upon it five or six drops of nitric acid, and heat the mixture strongly over a lamp till a dry red mass is obtained. Redissolve this mass in distilled water : and having filtered it, drop into it, succinate of ammonia. The iron contained in the sulphate of iron, having become highly oxygenized by the action of the nitric acid, a brown flocculent precipitate (succinate of iron) will be obtained. This precipitate, when heated, first by itself, and afterwards, with a little wax, at a low red heat, gives an oxide of iron containing 70.5 per cent. of metal. The first heating decomposes the succinic acid, and the second, reduces the metal to the state of a black oxide.

This succinate, however, precipitate also

alumine, provided there be no considerable excess of acid in the aluminous solution.

#### XLIX. SOLUTION OF STARCH.

A solution of starch in water, has of late received a place among the list of chemical re-agents, as a test for detecting iodine. Its action as such, was first made known, by professor Strohmeyer, of Gottingen. If a solution of starch be added, to a liquid containing a very minute quantity of iodine in an uncombined state, it produces with it, an indigo blue colour, and a precipitate (ioduret of starch) of the same hue, is slowly precipitated. The delicacy of this test is astonishingly great. It will indicate (according to Strohmeyer)  $\frac{1}{45000}$  th part of iodine in a liquid. Hence iodine, and starch, are tests for each other, and have been successfully employed as such, by M. de Claubray, who detected by means of starch, not only the presence of iodine, in the decoctions of the *fucus saccharinus*, but also its state of existence, or the

manner in which this singular substance is combined, in the body of the several varieties of sea plants which have furnished it. The blue colour, produced by the contact of iodine and dissolved starch, varies, according as either the one, or the other, of the substances, predominates. When the two bodies are in due proportion, the colour is a pure intense indigo blue; but it is black, when iodine prevails, and of a reddish blue or violet colour, when starch is in excess. When iodine is not present in the fluid, in a free, or uncombined state, it is necessary to add to the solution, a very minute portion of any acid, in order to disengage the iodine from its combination. Hence, if a solution of starch be dropt into a fluid containing hydriodic acid, or iodic acid, no change takes place, but if an acid be added so as to disengage the iodine, the starch then instantly shows the presence of this substance, by the indigo blue colour which it assumes.

The compound of starch and iodine, or ioduret of starch, is soluble in dilute sulphuric

acid, and the liquor is of a fine blue colour ; and with concentrated sulphuric acid, a brown compound is obtained, which becomes also blue when diluted with water.

#### L. SULPHATE OF SODA.

Sulphate of soda, or sulphate of potash, may be employed for detecting the presence of lead, by virtue of one of the constituent parts of this salt, namely ; the sulphuric acid, combining with the oxide of lead, and forming with it a white precipitate, (sulphate of lead) which is insoluble in water, and in liquid ammonia, but soluble in dilute nitric acid, when assisted by heat ; and which becomes blackened by water impregnated with sulphuretted hydrogen gas. These characters are sufficient to distinguish it, at once, from sulphate of barytes, with which it might otherwise be confounded ; because from what has been stated (page 196) this test must also produce a white precipitate with all the salts of barytes and of strontia. Sulphate of soda, or sulphate of

potash is chiefly of use, in such cases, where sulphuric acid, in an uncombined state, cannot be well applied as is often the case in the analysis of mineral waters. Dr. T. Thomson considers this test, "as the most unequivocal re-agent of lead which we possess;" for by means of it, he was enabled to detect in water the *one millionth* part of its weight of lead. (*See Analysis of the mineral waters of Tunbridge Wells by Dr. SCUDAMORE*, p. 57. 1816.)

## EXPERIMENT CLXIII.

Let fall into a test tube full of distilled water, a drop of super-acetate of lead, and add to the mixture a few drops, of a solution of sulphate of soda, or sulphate of potash, a dense white precipitate will fall down, which is sulphate of lead. Decant the super-natant fluid, pour upon the precipitate dilute nitric acid, and apply a gentle heat. The precipitate will again become re-dissolved. If water impregnated with sulphuretted hydrogen be added to it, it will become instantly blackened.

**LI.** CARBONATE OF AMMONIA.

Is made use of in combination with phosphate of soda, for detecting, and separating magnesia, (see p. 95) from other earths, when combined with them in solutions. It is also employed for separating, yttria, and glucine, from other earths; for both of which are soluble in a solution of this salt. Copper is detected by this re-agent, by imparting to the fluid containing this metal, a sapphire blue colour, (see page 160) and like the rest of the carbonated alkalies, it precipitates the solutions of earthy and metallic salts, and from the colour of this precipitate, the experienced operator may in some cases form a notion of the nature of the precipitate, obtained by means of this test.

**LII.** FLUATE OF AMMONIA.

This salt has been recommended as a test for lime, with which it produces a white precipitate (fluate of lime). But it is not discrimin-

native, because it effects also the salts with a base of magnesia, yttria, glucine, and perhaps alumine; its action upon the whole is much inferior to oxalate of ammonia, (page 170.)

### LIII. ALCOHOL.

Highly rectified alcohol, is of particular use in the analysis of mineral waters. When added to a liquid in large quantities it precipitates such saline bodies as are soluble in water and insoluble in alcohol. It is essential however, that the saline fluid, should be as concentrated as possible, and the quantity of alcohol added, should be, at least double that of the bulk of the fluid on which it is intended to act. Thus sulphate of lime, or selenite, may be precipitated by alcohol, from water, which contains this salt in the proportion of  $\frac{1}{1000}$ , provided the specific gravity of the alcohol is below .850. And alkaline sulphates may be precipitated, if the spirit is of a specific gravity, equal to .817. Besides, as al-

cohol dissolves some of the substances often found in mineral waters, and does not touch others, it enables us to separate these into two classes. Alcohol is also employed for detecting the adulterations of essential oils.

#### EXPERIMENT CLXIV.

Dissolve 30 or 40 grains of sulphate of magnesia, in  $\frac{1}{4}$  or  $\frac{1}{2}$  oz. of distilled water, put the solution into a test tube, and add to it two or three times its bulk of alcohol. The mixture will become turbid, and by degrees minute crystals of sulphate of magnesia will be deposited at the bottom of the glass. If instead of sulphate of magnesia, sulphate of soda, sulphate of potash, super-sulphate of alumine, or nitrate of potash, be employed, the same effect will take place.

#### EXPERIMENT CLXV.

Mix about five grains of acetate of potash, with any quantity of sulphate of potash, put

the mixture into a phial furnished with a stopper, and after pouring some alcohol upon it, set the mixture in a warm place to digest for 24 hours. Decant the fluid from the insoluble residue, and evaporate it to dryness. The product will be the acetate of potash which was added to the spirit, but the sulphate of potash will not have been touched. In a similar manner different substances, may frequently be separated from each other, by the mere action of alcohol.

Thus the greatest number of mineral waters contain some earthy salts, with a fixed acid, which remains in combination after boiling down the water to dryness, and which acid is seldom any other than the sulphuric and muriatic; and the earths, with which the acid is combined, are in general either lime or magnesia. Therefore only four earthy salts may be expected (not all together at once, for they would decompose each other) namely, sulphate of lime, muriate of lime, sulphate of magnesia, and muriate of magnesia. Now of these salts the sulphates, are perfectly insoluble in alcohol, but

the muriates are extremely soluble. This therefore affords a very convenient way of separating some of the salts. For this purpose, if we put the dry residue of the water, in a phial, and pour on it about five or six parts of alcohol, and let the mixture remain for some hours with frequent agitation, the alcoholic solution can contain only the muriates of lime and magnesia, provided the alcohol has been highly rectified ; if not, it will also dissolve a little muriate of soda, if present. The residue which is not dissolved by the alcohol, may contain the sulphates of lime and magnesia, of which the latter salt is easily soluble in water, but the former with great difficulty unless assisted by an acid.

#### EXPERIMENT CLXVI.

As many of the volatile or essential oils are produced but in small quantity, they are consequently high priced, and there is some temptation to adulterate them with fixed oils, to increase the quantity. It is therefore of con-

siderable importance, to be able to detect such frauds, which may be done in the following manner:—Mix a few drops of oil of almonds, or olives, with any essential oil, for instance with oil of lavender, and pour alcohol upon it. The oil of lavender will dissolve in the spirit, and the oil of almonds remain behind undissolved. Decant the alcoholic solution from the oil of almonds, and add distilled water to the former; the water will unite with the alcohol, and by this means the essential oil of lavender will be separated. An additional examination, may be the following: let a single drop of the oil which is suspected, fall on clean paper, and expose it to a gentle heat. If the oil be pure, the whole will become evaporated, and no trace or spot remain on the paper; but if it has been mixed with a fixed oil, a greasy spot will remain behind. When essential, or volatile oils, are adulterated with alcohol, it is easily detected by mixing a little of the oil, with water, which immediately produces a milkiness, by the abstraction of the alcohol from the oil, and its combination

with the water. Volatile oils are frequently adulterated with oil of turpentine ; but this can only be detected by the peculiar odour, of oil of turpentine which continues for a longer time than the odour of the other volatile oils.

#### LIV. SOLUTION OF SOAP.

A solution of soap in alcohol is of some use, as a test, for ascertaining what is vulgarly called, the *hardness* of waters ; because when added to pure water, it produces no change, but when dropped into water loaded with earthly, or metallic salts, it occasions, a milkiness ; and a flocculent precipitate is formed. And from the degree of milkiness, and the quantity of the precipitate produced, some notion may be formed of the quality of the water, at least, so far as regards its fitness for the purposes of washing, dying, bleaching, boiling ileguminous and cereal seeds, and other purposes of the culinary art and domestic œco-

nomy, for which water as pure as possible ought to be employed.

#### EXPERIMENT CLXVII.

Into a test tube half filled with distilled water, pour a few drops of a solution of soap in spirit of wine, and no alteration will be produced.

#### EXPERIMENT CLXVIII.

To a like quantity of common pump or spring water, add a few drops of solution of soap, a milkiness will instantly ensue, and a flaky precipitate will be deposited if the mixture be left undisturbed for some hours. The milkiness is owing, to the presence of earthy salts, which in pump water, are usually sulphate and carbonate of lime : the alcali of the soap leaves the oil, with which it was chemically combined, and unites with the acid of the earthy bases of the salts which are present in the water, and the oil joins the earth and produces with it an insoluble precipitate, or earthy soap

The action of this test is therefore not discriminative, and it can serve only to indicate the presence or absence of those kind of substances which occasion that quality in water, which is usually called *hardness*, and which is chiefly owing to salts with an earthy or metallic base.

#### EXPERIMENT CLXIX.

Having impregnated a small quantity of distilled water with carbonic acid gas, dissolve in it, a few grains of white marble, or magnesia, and after the liquid is poured off clear, from the insoluble residue, add to it a few drops of the solution of soap, and in a like manner, a white curdy precipitate will be produced.

#### EXPERIMENT CLXX.

Dissolve a few grains of sulphate of magnesia, or muriate of lime, or of alum, in half a wine glass full of distilled water, and add to the mixture, a few drops of the solution of soap,

the fluid will become milky, and deposit a white flocculent precipitate.

The same effect will be produced with any other earthly or metallic salt.

#### EXPERIMENT CLXXI.

Mix a drop of a solution of sulphate of iron, or any other metallic salt, with half a wine glass full of distilled water; and add to it, a few drops of a solution of soap; this will in a like manner become turbid, and a great number of flakes will be deposited.

#### LV. WINE TEST.

This test is nothing else but water impregnated with sulphuretted hydrogen gas, combined with a small portion of muriatic, or any other weak acid. It is employed chiefly for readily distinguishing iron, from lead, in wine. By adding this test to wine, or any other liquid suspected to contain lead, the liquor, if iron only be present, will remain transparent, and

no precipitate will be formed, but if it contains the minutest portion of lead, the test will occasion a black muddy precipitate (which is sulphuret of lead); because the weak acid combined with the sulphuretted hydrogen, is not capable of dissolving sulphuret of lead; and this precipitate when fused before the blowpipe with a minute portion of lime or fine iron filings on a charcoal support, then yields a globule of metallic lead. This test, however, is not discriminative, because iron dissolved in acetic, or in any other vegetable acid, is also precipitated by it. It likewise yields a black precipitate, with solutions of iron in general, provided a minute portion of acetate of potash be added to the fluid, prior to the addition of the test liquor.

#### LVI. ZINC.

Metallic zinc, is chiefly employed, as a re-agent for separating copper, lead, tin, silver, and tellurium in a metallic state, from their solutions in acids. It also precipitates lead,

tin, copper, and tungsten, from their alkaline solutions; but it is seldom employed for that purpose, because we have better means (acids) of effecting the decomposition of these solutions.

When zinc (and in fact any metal) is employed, to separate another metal in a metallic form, from its solution, in an acid, it is essential that the fluid should have a very slight excess of free acid; for otherwise, a portion of the metal is thrown down either in the state of an oxide or as an alloy.

#### EXPERIMENT CLXXII.

Add to a wine glass full of distilled water, a small quantity of the solution of super-acetate of lead, mixed with a few drops of acetic or nitric acid, and immerse into the fluid, a slip, or a piece of zinc. The lead contained in the solution, will immediately become precipitated upon the zinc, in the form of a metallic and moss-like appearance, and of a dark bluish gray colour.

## EXPERIMENT CLXXIII.

The precipitation of lead, which has been long known by the name of the *lead tree*, may be here mentioned. It is accomplished in the following manner :—Into a quart decanter, nearly filled with soft or rain water, put  $\frac{1}{2}$  oz. of super-acetate of lead, (sugar of lead of commerce) reduced to powder, shake the mixture, and suffer it to stand undisturbed for two or three days ; then decant the clear fluid from the insoluble residue ; (if any,) reject the latter, and after having rinsed the decanter with water, return into it, the clear solution. If now a ball of zinc be suspended in the middle of the fluid, by tying it to a thread affixed to the stopper of the bottle, and the vessel be then set in a place where it cannot be disturbed, the zinc soon becomes covered with a moss-like substance of metallic lead, which increases gradually, and shoots out brilliant crystalline plates of metallic lead, which place themselves in a kind of symmetrical arrangement somewhat resembling a tree, or shrub.

The zinc has a greater affinity than lead, for oxygen, it deprives the oxide of lead of it, which being thus reduced to the metallic state, can no longer remain in combination with the acetic acid, but becomes precipitated upon the zinc. The theory of voltaic electricity, has of late shown that this phenomenon, (like all other metallic precipitations, is the result, of a voltaic action, produced, between the bodies brought into contact. Namely : when the precipitation of the metallic lead takes place on the surface of the zinc, voltaic electricity is evolved, in consequence of an easily oxidable metal coming into contact, together with a fluid, with another metal, which is more difficultly oxidizable. A galvanic circle being thus formed, part of the water of the interposed fluid, becomes decomposed, one of its constituent parts, namely, the oxygen, becomes attracted by the metal positively electrified, (the zinc,) whilst its other constituent part, the hydrogen, is attracted by the metal negatively electrified, namely, the lead; it there acts in producing

the further reduction, by abstracting oxygen from the metallic oxide dissolved in the acid, and the particles of the reduced metal, are gradually deposited, at that extremity; and the accretion of the metallic crystals taking place from the metallic filaments already formed, spread out and arrange themselves somewhat like a shrub or tree.

The theory of the reduction of other metallic precipitates from their solutions, is precisely analogous to this statement.

#### EXPERIMENT CLXXIV.

Immerse a bar, or a slip of laminated zinc, into a dilute solution of sulphate of copper, having an excess of acid; a precipitation of metallic copper will immediately take place, and the zinc will become incrusted with a coat of copper. The copper may readily be detached from the zinc; it is advisable to digest it in muriatic acid, which will dissolve any zinc, if part of it should happen to adhere to the copper. and besides unless there

is, a considerable excess of acid in the solution, a portion of the copper is always precipitated as an oxide, and which is thus completely removed by the muriatic acid.

#### EXPERIMENT CLXXV.

Add to half a wine glass full of distilled water, 8 or 10 grains of submuriate of tin, and immerse into this fluid, a slip of zinc; the tin will immediately become precipitated in a metallic state surrounding the zinc, in the form of a spangled moss-like coating.

Mr. Silvester has recommended a galvanic circle formed of zinc and gold, as an active agent for detecting corrosive sublimate, if applied in the following manner.

#### EXPERIMENT CLXXVI.

Let a piece of zinc wire, about three inches long, be twice bent at right angles so as to resemble the Greek letter  $\pi$ , so that the two legs of this figure be distant about the diameter.

ter of a common gold wedding ring from each other, and let the two ends of the bent wire be afterwards tied to a ring of this description. Then take a plate of glass, not less than three inches square, lay it as nearly horizontal as possible, and on one side, drop some sulphuric acid, diluted with about six times its weight of water, till it spreads to the size of a halfpenny. At a little distance from this, towards the other side, drop some of the solution, supposed to contain corrosive sublimate, till the edges of the two liquids join together, and let the wire, and ring, arranged as above stated, be placed in such a way that the wire may touch the acid, while the gold ring is in contact with the suspected liquid. If the minutest quantity of corrosive sublimate be present in the fluid, the ring in a few minutes will then become covered with metallic mercury, on the part which touches the liquid. In this manner the minutest quantity of mercury may be discovered, when present in any liquid.

## LVII. IRON.

Polished iron wires, bars, or plates, are useful re-agents for precipitating copper in a metallic state from its solution in acids. Iron likewise precipitates antimony and tellurium in a metallic form from acid solutions.

## EXPERIMENT CLXXVII.

Immerse the blade of a knife, a key, or any other piece of polished iron or steel, for a few seconds, into a solution of sulphate of copper, having a slight excess of sulphuric acid; the knife when withdrawn will be covered with a coat of metallic copper. To obtain the copper in a pure state, the precipitated metal ought to be digested in dilute muriatic acid.

## LVIII. TIN.

This metal is useful as a test for detecting the presence of gold, with the solutions of

which it produces a purple coloured precipitate. If a slip, or a bar of tin, be immersed into a solution of muriate of gold, the surface of the tin becomes immediately covered with a deep purple coloured powder, which becomes gradually diffused through the whole fluid, and imparts to it the colour of red wine. The powder thus produced speedily subsides and leaves the solution of gold colourless. This powder is similar to the precipitate produced by sub-muriate of tin, and muriate of gold. See sub-muriate of tin, p. 156.

#### EXPERIMENT CLXXVIII.

Add to half a test tube full of distilled water, a few drops of muriate of gold and immerse into it, a piece of tin, or a tin-wire. In a short time a violet or purple coloured precipitate will fall down; which is a compound of gold and oxide of tin. See page 156.

## LIX. COPPER.

Is used in analytical experiments chiefly as an agent for separating silver in a metallic state from its solutions. When a bar or rod of this metal, is immersed in a solution of silver in an acid, it becomes superficially of a blackish colour, and after a while, the silver is precipitated upon the copper in a metallic state. The whole of the silver is not however separated by the copper, for the solution becomes milky, on adding to it common salt or muriatic acid. Still it is a very convenient way of recovering the silver immediately in the metallic state. If the solution has no considerable excess of acid, the latter portion of silver thus precipitated, contains a minute portion of copper, but this may be prevented by adding to the fluid, a slight excess of nitric acid, or bringing the precipitate again into contact with a solution of nitrate of silver.

This process is followed in the art of assaying, to recover the silver which has been alloyed with gold, and which, in the operation

of *parting*, has been dissolved by nitric acid; plates of copper being put into the solution, so as to precipitate the silver. It is also frequently employed to obtain silver free from other metals with which it has been alloyed.

#### EXPERIMENT CLXXIX.

Add to half a wine glass full of distilled water, five or ten drops of the solution of nitrate of silver, and immerse into it, a bar or slip of copper. The silver will immediately be precipitated upon the surface of the copper in a brilliant metallic form.

This experiment may be pleasingly varied in the following manner.

#### EXPERIMENT CLXXX.

Spread on a plate of glass a few drops of nitrate of silver diluted with double its quantity of distilled water, place at the bottom of it, flat upon the glass, and in contact with the fluid, a copper wire, bent to any figure,

and let the whole remain undisturbed in an horizontal position. In a few hours a crystallisation of metallic silver will make its appearance upon the glass next the piece of copper wire, and the arrangement of crystals will extend gradually till the whole quantity of fluid is decomposed.

## LX. QUICK-SILVER, AND SILVER LEAF.

Both these metals are useful for discovering minute portions of sulphuretted hydrogen gas, or sulphurets in general, particularly when contained in mineral waters; because the metallic brilliancy of these metals, becomes destroyed when they are suffered to be immersed in a fluid containing sulphur in a loose combination.

## EXPERIMENT CLXXXI.

Fill a phial with water impregnated with sulphuretted hydrogen gas, and add to it a few globules of mercury free from dust, or a silver leaf; in a short time the metal will lose its

metallic splendour; and its surface will become covered with a brown pellicle, which is a combination of sulphur with the metal.

#### LXI. FLUXES FOR THE BLOWPIPE.

The term flux is applied in chemistry to those substances which are added to minerals, metallic ores, or other bodies, to assist their fusion when exposed to the action of fire. Thus potash or soda, in a pure state, or as sub-carbonats are fluxes for flint, and all kinds of siliceous minerals, because when flint is mixed with these bodies in a proper proportion and heated, these alkalies cause it to melt, and the compound is a vitreous mass; and boracic acid, and borax, are fluxes for clay and argillaceous minerals, &c. These bodies therefore act upon refractory substances, in the *dry way*, as water, acids, and other liquids act (which are used to dissolve solids) in the *humid way*. The manner in which each mineral is effected when it is heated with different fluxes, its fusion, more or less quick or

slow, easy or difficult, complete or incomplete, liquid or pasty, the kind of mass which results from it, opake, transparent, vitreous or enamelled, scorified, or dense and compact, the colour which it principally affects, and which almost always depends on the nature and the proportion of the metallic matters which it contains—these form so many useful characters employed by analytical mineralogists to discover and distinguish each species of the several compounds ; and when the external characters or the sensible properties do not suffice to determine with accuracy the kind or species, this action of the fluxes employed with the blowpipe is frequently very useful to that determination, by removing doubts, destroying uncertainties, and explaining the general nature of the mineral.

It may easily be imagined that the nature of the products will greatly vary, according to that of the flux which enters into combination with them; and accordingly fluxes are varied in experiments according to the object in view.

The fluxes which are used for the blow-pipe experiments, and in all the laboratory operations in general, are chiefly compound bodies belonging to the class of salts. One of the constituent parts of these bodies frequently acts chemically : thus the alkaline and earthy part of fluxes often combines, with the acid which may be attached to a metallic oxide, and which would prevent its reduction to the metallic state if not separated ; whilst others again act merely mechanically. And further, many of the metals will retain their oxygen so forcibly, that the application of heat is totally incapable of expelling it, when the object is to obtain the metal. The addition of inflammable matter becomes therefore expedient to carry off the oxygen in the form of gas. The oxide to be reduced is therefore mixed with a portion of inflammable matter, and is then exposed to an intense heat ; and to obtain the reduced metal in a coherent mass, and not in small grains, a substance must be also present, which is capable of being readily melted, and of allowing the metal to subside through it, so as

to cause the particles to conglomerate and to form a collected button, instead of scattered grains, which would otherwise happen. And it would be extremely laborious to collect together the minute particles, if they were not thus enabled to descend, and permitted to unite at the bottom of the crucible. The action of fluxes are therefore in general, both mechanical, and chemical.

The fluxes which have obtained the general sanction of chemists, on account of their extensive use, are, phosphate of soda, (page 95) sub-borate of soda (page 157) and boracic acid (page 62), besides these, fluor spar, gypsum, sub-carbonate of soda, nitrate of potash, and glass, are occasionally employed in the blow-pipe assay. These bodies are reduced to powder, and mixt up with the substances upon which they are to act. See pages 62, 95, 157. What is called *whiteflux* is a mixture of a little potash with carbonate of potash, and is prepared by deflagrating together equal parts of nitrate of potash and supertartrate of potash. When an oxide is at the same

time to be reduced, the flux called *black flux* is to be preferred, which is produced by the deflagration of two parts of supertartrate of potash, and one of nitrate of potash. It differs from the former only in containing a little charcoal. Soap likewise promotes fusion by being converted by the fire into carbonate of soda and charcoal, and therefore also acts as a flux, and is frequently employed as such in the laboratory.

LXII. BLOWPIPE,  
AND  
ITS APPLICATION.

The blowpipe in chemistry and mineralogy, is an instrument of the greatest utility. It enables us to expose to the action of a most violent heat, any substance we may meet with, in order to ascertain its general nature or qualities with regard to fire: every effect of the most intense heat of furnaces may instantly be produced by this instrument; and with this advantage, that the process is expeditious, and under the inspection of the operator;

whereas we can only conjecture what passes in the centre of a furnace, if the same experiment be made in the laboratory way. The most expensive materials, and the minutest quantity of bodies, may be used, and the whole process instead of being carried on in an opake vessel, may instantly be varied under the eye of the observer, and may be seen from beginning to end. Indeed many advantages may thus be derived from the use of this simple and valuable instrument. Its smallness, which renders it suitable to the pocket, is no inconsiderable recommendation to the travelling mineralogist. It is true that very little can be determined in these miniature assays, concerning the actual quantity of products ; but in most cases a knowledge of the contents of any mineral substance, is a great acquisition, which is thus obtained in a very short time, although the actual quantities of the products discovered, are too minute to enable the operator to ascertain their relative proportions.

Thus for example, if we meet with a spe-

cies of clay, and wish to know whether it be fit or not for the purpose of making porcelain, the blowpipe assay will decide the question. Because, for the purpose of making the finer kinds of pottery and porcelain, it is essential to have a clay which *after burning* remains perfectly white. The appearance of these substances, before burning can never be depended on, for though often the whitest clays before burning, are those which remain white afterwards, it is only in a few districts where clays are found that remain absolutely white. And many white clays are to be found, which when burnt become more or less coloured, and again many black clays burn perfectly white. The nature of *lime stone*, may readily be discriminated by means of this instrument. Lime stone fit for making mortar and cement, does not melt by itself, but becomes more or less white after being violently heated by the blowpipe flame, and if suffered to cool and then mixed with water, becomes hot. This proof is best made by putting the minute portion of the assayed

stone on the outside of the hand, and letting fall on it a drop of water, when a quick heat will be felt on the skin. *Siliceous stones* never melt alone, but form a glass with borax and soda; argillaceous stones when pure do not melt, but become white and acquire a flinty hardness. Fluor spar, becomes phosphorescent, and melts, into an opake white slag; zeolites melt easily and foam in the flame.

And from the colour which the substances called fluxes acquire, much useful information may be drawn concerning the nature of the mineral under examination. Thus for example, gold imparts to borax, and phosphate of soda, and boracic acid, a ruby colour. Silver, tinges these fluxes orange yellow; copper produces with the same fluxes a bluish green pearl; iron tinges them green, of different intensities and hues; tin produces a white, or greyish white opake enamel; antimony affords a hyacinth coloured glass, and flies off partly in white fumes, and a white powder, or oxide of antimony is deposited on the surface held near the fixed substance.

Arsenic likewise diffuses white fumes, when heated on charcoal, and produces a garlic like odour, cobalt stains a large quantity of borax intensely blue, and forms with it a blue glass. Oxide of manganese yields with the inner point, or the blue flame, a violet coloured bead, which with the interior part of the flame become again colourless, and which may be made alternately to disappear, and re-appear at pleasure. These successive changes of colour, which are peculiar to the oxide of manganese, may be shewn in the following manner.

#### EXPERIMENT CLXXXII.

Melt a small quantity of phosphate of soda, or glass of borax, with the blowpipe flame upon a piece of charcoal, and add to it a very small portion of black oxide of manganese, (melt the mixture together by the inner blue flame,) the globule will assume a violet or purple colour. Then fuse it again, and keep it in a melted state for a longer time, the

effects of which will be that the violet colour again vanishes. This being effected, melt the colourless globule by the exterior flame of the blowpipe, and the purple colour will re-appear, but becomes, as before, again destroyed by a longer continuance of the heat. The smallest particle of nitre laid upon the globule, also immediately restores the red colour. If the globule when colourless be now melted in a silver spoon, or on an iron plate or any metallic support, instead of being on the charcoal, the violet colour returns, and will not be again removed by any continuance of heat, so long as it remains on the metallic support.

Some minerals when exposed to the blowpipe dart, are perfectly infusible by it; others melt with facility; some are partly volatilized, others burn with a flame of a peculiar colour; in some the colour is changed at different temperatures, as in the oxide of manganese, some fuse with intumescence: others decrepitate, or exfoliate, when urged by the flame, or lose their colour; in some the fusion is partial; sometimes the result is a kind of ashes or

powder, in many cases it is a complete vitrified globule, transparent, or opaque, or of various colours. Some afford a mere scoria or cinder, others produce an enamel, and some give a mere *frit*. All these gradations of phenomena, are so many means of discovering, and of estimating the differences particularly of earthly minerals, and they contribute also to the knowledge and the determination of the particular species of the individual which afford it.

It requires a little art to keep up an uninterrupted blast of the blowpipe with the mouth, which is not easily described; but may readily be acquired by practice. The act of breathing must be carried on through the nostrils without interruption, and the stress of blowing must be performed merely by the compression of the cheeks upon the air in the mouth. Beginners blow generally too strong, which obliges them to take breath very often. The whole art consists in inspiring the air through the nostrils, whilst the air contained in the mouth is forced out through the blow-

pipe, so that the action of the nostrils, lungs, and mouth, resemble the action of double bellows; and to accomplish this object, there is no necessity of blowing violently, but only with a moderate and aquable force, and then the breath can never fail the operator. This art of blowing properly is by some acquired in an instant, while others are a long time in making themselves masters of it. To those who experience any difficulty in the free use of the blowpipe, the following directions may be of service. First, let the learner accustom himself to breathe freely with the mouth shut; then in making an expiration, let him transfer the air into the mouth, till the cheeks are moderately inflated, and retaining it there, let him discharge the surplus of the expiration through he nostrils, and then make two or three easy inspirations and expirations through the nostrils, without allowing the air in the mouth to escape. When practice has rendered this easy, which may be effected in half an hour, let the nozzle with the smallest aperture be fixed on the jet tube of the blowpipe,

and introduce the mouth piece within the lips ; then inflate the cheeks by an expiration, and continue breathing easily through the nostrils, till nearly the whole of the air has passed out of the mouth through the tube ; then renew the air as before, and after a few days practice, the muscles of the mouth will be accustomed to this new mode of exertion, and an uniform uninterrupted stream of air may be kept up for half an hour without any extraordinary fatigue.

The best kind of flame for blowing through with the blowpipe, is a thick wax or tallow candle with a very large wick, which should be kept snuffed moderately low, and the wick turned a little aside from the pipe ; the spirit lamp may also be used, it makes a perfectly clear flame without smoke, but weak in comparison to a thick wax candle ; although a wax candle is the most convenient, a thick tallow candle will do very well. The candle should be snuffed rather short, and the wick turned on one side towards the object, so that a part of it does lie horizontal. The stream

of air must be blown along this horizontal part as near as may be without striking the wick. If the flame be ragged and irregular, it is a proof that the hole of the blowpipe nozzle is not round or smooth; and if the flame have a cavity through it, the aperture of the nozzle pipe is too large. When the hole is of a proper figure, and duly proportioned, the flame consists of a neat luminous blue dart or cone, surrounded by another flame of a more faint and indistinct appearance. Too great a flame does not easily yield to the blast, and too small a one, produces a weak effect.

In using the blowpipe, the following observations should be attended to. The end of the nozzle pipe must be just entered into the flame, and the current of air will then throw out a cone or dart of flame from the opposite side. If it is well managed, this dart or cone will be very distinct and well defined. Care must be taken that the stream of air does not strike against any part of the wick, as it would then be disturbed, and split into several parts. The jet or blast of air must be deli-

vered somewhat above the wick; and as, unless the flame was considerable, there will not be sufficient for the stream of air to act upon, for this reason the wick is best to be opened, because it then exposes the largest surface, and produces the greatest flame; the stream of air from the pipe should then be directed through the channel or opening between the wick, so as to produce a cone the most perfect and brilliant directed, downwards, at an angle of about 45 degrees.

Its intensity is different according to the different parts of the flame. The place where this intensity is strongest, is the extremity of the blue point of the flame.

Every substance intended to be assayed with the blowpipe, should be heated very gradually, the flame should be directed very slowly towards it, in the beginning, not directly upon it, but somewhat above it, and so approaching nearer and nearer with the flame, until it becomes red hot. Whenever any mineral substance is to be tried we do not immediately begin with the blowpipe; because

minerals are not always homogeneous, or of the same kind throughout, although they may appear to the eye to be so. A *Magnifier* is therefore necessary to enable us to discover the heterogeneous particles, if there be any, and these ought to be separated, and every part tried by itself, that the effects of two different things examined together, may not be attributed to one alone.

The substance upon which the flame acts ought to be proportioned to the size of the flame to which it is exposed. If the aperture of the blowpipe is only of the diameter of a common pin, the substance ought not to be larger than a pepper corn. In order to support the substance, it may be laid upon a piece of close-grained well-burned charcoal, made of elm or poplar wood. A small shallow hole may be scooped out with a knife, on the piece of charcoal, and the substance laid upon it. The charcoal itself kindles all round the hole, and the hole is thus gradually enlarged; and the heat too is kept up round the substance much more uniformly than

when a metal support is used. At the same time however the chemical effect produced by ignited charcoal should not be forgotten, particularly in the reduction of metallic oxids, and the deoxygenation of the fixed acids; so that, for example, a small heap of oxide of copper, lead, or tin, heated red-hot on charcoal by the blowpipe, is speedily reduced to a metallic state, hence also fragments of tin stone, (tin ore) common lead ore, or galena, ruby copper, &c. are easily reduced when heated on a charcoal support.

Very small and brittle substances are apt to be carried away by the current of flame from the piece of charcoal. These may be secured by making a deep cavity in the charcoal, into which the substance is to be put, and covered with another small piece of charcoal, which partly protects it from the flame. Some experiments of reductions are best made by binding two flat pieces of charcoal together, cutting a channel along the piece intended to be uppermost, and making a cavity in the middle of this channel to contain the

matter to be examined. With this contrivance the flame may be urged through the channel between the two pieces of charcoal, and thus violently heats the substance in the cavity, which may be considered as in a closed furnace.

Those bodies upon which charcoal acts chemically (but when intended to be exposed to the blowpipe flame, without suffering such changes to take place,) may be placed in a small spoon, somewhat less than a quarter of an inch in diameter, made of gold, silver, or platina. The spoon must of course be properly fixed into a wooden handle. Silver or gold spoons are best adapted for fusions with alkaline fluxes, for which those made of platina are entirely unfit; they have nevertheless the capital disadvantage that they will only bear a dull red heat without risk of melting, whereas spoons of platina are perfectly infusible by the blowpipe flame.

A small forceps entirely made of platina, is also very convenient and useful for easily ex-

posing fragments of stones, to the dart of the blowpipe, because these bodies may be held with them, and the forceps cannot be melted nor oxidated, nor does it become too hot to be held by the fingers during trial, on account of the bad conducting power of the metal of which it is fabricated. They are also convenient for handling or taking out from the melted fluxes, the small bead of the product.

Flatteæd platina wire is another very useful article for exposing fragments of infusible substances to the action of the blowpipe flame. The fragment may easily be secured between a piece of the wire bent round it, and may thus be firmly held in any direction we chuse.

Platina foil, is likewise very serviceable for exposing to the flaine of the blowpipe such substances as readily split, and are dispersed when heated by the blowpipe dart on charcoal or when held by the forceps or placed in the spoon, or when secured between platina wire. Any substance, wrapped up in a piece of thi-

foil, may readily be kept steady during trial, and hence it is best adapted for pulverulent substances. Slender filaments of cyanite or of asbestos may also be employed occasionally.

The best blowpipe for chemical and mineralogical purposes, is the so called *Pocket Blowpipe*\* invented by Mr. Pepy's, which is sufficiently known, and does not require to be described.

### LXIII. WATER IMPREGNATED WITH CAR.

BONIC ACID GAS,

OR

LIQUID CARBONIC ACID.

As water impregnated with carbonic acid gas, is one of the articles requisite for the per-

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\* Complete sets of *Pocket Mineralogical Blowpipe Apparatus*, of different kinds, and *Mineralogical Travelling Chests*, may be had with this Treatise.

formance of several of the experiments exhibited in this treatise, (*see pages 11, 14, 19, 24, 25, 32, 33, 36, 43, 100, 178, 192*), and as this article cannot be readily procured on all occasions we shall give a description of an *extemporaneous* apparatus, by which means this fluid may easily be prepared. The apparatus is exhibited on the title page.

It consists of a common earthern ware basin (a wash-hand basin) across the rim of which is placed, a wooden board four or five inches wide, and about  $\frac{1}{4}$  of an inch thick, having a slit terminating in a hole, cut in the centre of the board, which hole serves to receive the inverted common quart bottle *a*, as shown in the drawing. *b* is a similar bottle, furnished with a bent glass tube *c*, which connects the two bottles, and serves to convey the gas, from the bottle *a* to *b*; for one extremity of this tube passes air tight through the cork in the neck of the bottle *b*, whilst the other end is inserted into the neck of the inverted bottle *a*. To impregnate water with-

carbonic acid gas, (or with any other gas which is not absorbable by water,) by means of this apparatus ; let the bottle *a* be filled with water, quite full, stop it with a cork, and invert it with its neck downward into the earthenware basin, also previously filled with water, and let it rest in the centre hole of the board, as represented in the design, and then withdraw the cork. This being done put some white marble, lime-stone, or common chalk, broken into pieces of the size of a pea, into the bottle *b*, and pour upon it, common muriatic acid diluted with two or three times its bulk of water. The carbonic acid gas which becomes extricated by the action of the acid upon the marble, will pass through the bent glass tube *c*, and enter the bottle *a*, from which it expels the water, and the bottle thus becomes filled with carbonic acid gas. When this has been effected, cork the bottle, in its inverted position, with its neck under the surface of the water ; and having next removed it out of the basin, pour into it about half

a pint of distilled water, cork it again perfectly air tight, shake it for about three or four minutes, and then suffer it to stand for two or three hours, taking care to agitate it during that time frequently. The water will thus become strongly impregnated with carbonic acid gas, (or become converted into an artificial seltzer water;) it will send forth a multitude of air bubbles when exposed to the air, and particularly when poured from one vessel into another, or when gently warmed. The colder the water is, the more carbonic acid gas will be absorbed.

It is obvious that a quantity of carbonic acid gas equal to the portion of water poured into the bottle, is wasted, but this is not an object, and this loss may even be avoided by inverting the bottle filled with carbonic acid gas, into a small cup containing distilled water, and suffering it to stand for a few hours, or till a sufficient quantity of the water has ascended into the bottle, and has become impregnated with the gas.

Instead of the glass tube *c*, a common *gas* or *proof bottle* of this shape



may be used, which in fact is more convenient than the glass tube *c*. *a* is the body of the gas bottle, into the neck *c* of which is ground air tight, the bent tube *b*, for conveying the gas into any inverted vessel. The bottom of the body *a* being made round and of thin glass, will bear a moderate heat, without the risk of cracking.

From marble may be obtained in this way, from 40 to 45 per cent. of its weight of carbonic acid gas, so that 100 grains will produce between 90 and 100 cubic inches.

LXIV. WATER IMPREGNATED  
WITH  
SULPHURETTED HYDROGEN GAS,  
OR  
LIQUID SULPHURETTED HYDROGEN.

This fluid which is not met with as an article of commerce, and which is likewise necessary for the performance of several experiments exhibited in this treatise, (*see pages 13, 14, 21, 91, 118, 134, 142, 144, 145, 146, 219, 251*), may easily be prepared for immediate use in the following manner :

Put into the *gas bottle*, exhibited page 255, one part of sulphuret of antimony of commerce, broken into a coarse powder, and pour upon it 3 or 4 parts of common concentrated muriatic acid, and assist the action of the acid, by a gentle heat of the spirit lamp, sulphuretted hydrogen gas will become disengaged from the materials, and which may be made to combine with distilled water, as directed above, for combining water with car-

bonic acid gas (p. 253). It is advisable to let the first portion of the gas which becomes liberated, escape, because it is mingled with a portion of common air contained in the gas bottle.

Instead of sulphuret of antimony, sub-sulphuret of iron may be used. (but the former substance yields the purest gas). The sub-sulphuret of iron may be put into the quart bottle *b*, and common muriatic acid diluted with half its bulk of water must be poured upon the sub-sulphuret. Sulphuretted hydrogen gas will be liberated, in abundance, and may be made to combine with distilled water, in the manner stated. Distilled water takes up about  $\frac{3}{4}$  of its bulk of sulphuretted hydrogen gas; and acquires from it, a sweetish and very nauseous taste, and strong foetid odour resembling the smell of putrid eggs, or a foul gun-barrel when wetted. The Harrogate and Moffat waters are natural solutions of sulphuretted hydrogen in water. The former contains no more than about one-twelfth of its bulk of this gas. Water impregnated with

sulphuretted hydrogen gas does not keep for a long time, even when preserved in corked bottles; because the hydrogen quits the sulphur, which then becomes precipitated in the form of a white powder. But for the performance of the experiments exhibited in this treatise, the water, when kept in a dark place or opaque and well corked bottle, retains a sufficient strength for two or three months.

The sub-sulphuret of iron, may be obtained by melting together in a covered crucible for a few minutes, three parts of iron filings, and one of flowers of sulphur; or a crucible may be half filled with common iron pyrites, covered with half its weight of iron filings, and putting over this, a layer of charcoal powder, and then exposing the whole to a dull red heat for  $\frac{1}{2}$  hour.

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## F I N I S.

DESCRIPTIVE  
**CATALOGUE**  
OF THE  
**APPARATUS & INSTRUMENTS**  
EMPLOYED IN  
EXPERIMENTAL AND OPERATIVE  
**CHEMISTRY,**  
IN ANALYTICAL MINERALOGY,  
AND IN THE  
PURSUITS OF THE RECENT DISCOVERIES  
OF  
**VOLTAIC ELECTRICITY.**

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BY ACCUM AND GARDEN,  
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COMPTON STREET, SOHO, LONDON.

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1816.

## CHEMICAL

# APPARATUS AND INSTRUMENTS.

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### MOVABLE UNIVERSAL FURNACE, *fig. 1, plate xvi.*, Gl. 16*s.* to 8*l. 8*s.**

AMONG the whole group of apparatus designed for applying heat to bodies, this furnace undoubtedly is for the purposes of experimental chemistry the most useful, however numerous and different the operations to be performed may be. It may be used with perfect safety in a room, and is therefore well calculated for those operators who have no access to the laboratory, as well as for public lecturers on chemistry. A very large number of chemical processes may be carried on in this furnace immovably and at a cheap rate.

For the smelting of metallic ores, or for operating with the crucible, the vessel with its stand or support is placed on the grate, in the midst of the fire, the larger opening, *a*, or mouth of the furnace, is closed with a cover, *b*, and the fuel introduced at the top, or through one of the arched openings, *cc*. The sight-hole *d*, in the centre of the cover, serves to watch the progress of the operation and the state of the fire. This hole is also convenient for passing through it, an iron rod, to stir up the matter contained in the crucible, or to withdraw from time to time a portion for inspection.

When distillation by the naked fire is to be performed with this furnace, a retort is placed in the fire, on a crucible stand, and the beak of it, is made to pass through one of the front openings *cc*. The same proceeding may be used to obtain such gases as cannot be disengaged, without exposing the materials that afford them to a red heat, viz. oxygen from oxid of manganese, gaseous oxid of carbon, &c.

For distillation, or sublimation from the glass retort, or the alembic, the cover, *b*, is removed, and the iron sand-pot, *c*, put in its place; the fuel then is added through one of the front openings, *cc*. In this sand-bath may likewise be placed flasks, digesters, matrasses, evaporatories, and other vessels, to receive an uniform, safe, and gradual heat.

For evaporation by the water-bath, a shallow pan, (*fig. 8 and 17, pl. iii.*) filled with water, and placed on the mouth of the furnace, may be employed.

For roasting metallic ores, and other minerals, to free them from sulphur, arsenic, &c. a musle should be placed, or better fitted with clay, in the lower arched opening, *c*; the fuel is then introduced at the top mouth, *a*. To assay gold or silver, and to enamel or paint on glass, the same arrangement is convenient.

The decomposition of water, by passing steam over ignited iron or charcoal, may be performed by laying an earthenware tube or gun-barrel through the two circular side openings, *f*, opposite to each other, and at right angles with the perpendicular of the furnace. The middle part of the barrel may thus be made red hot, whilst each extremity is readily kept cool, and may be connected with any kind of apparatus.

For evaporating by the naked fire, the iron rings, *fff*; (fig. 19, pl. iii.) which are of different sizes, serve to lessen the upper opening of the furnace on which they are put, so as to adapt it to the size of the evaporatory vessel, whatever its diameter may be. The largest ring is first placed on the mouth of the furnace, the second in size is put on the first, &c. until the opening is sufficiently lessened.

The different apertures which are in the front and sides of this furnace are provided with solid stoppers of crucible ware, fitted by grinding, to close the apertures accurately, whenever one or the other is not employed; they are further covered with iron doors moving on hinges, to keep out the air effectually.

The register doors at the ash-pit, serve as dampers to regulate the heat with precision, by admitting or excluding air at pleasure, when more or less opened or shut. To increase the draught of the fire on particular occasions, an iron pipe, eight, ten, or twelve feet long, and not less than four or five inches in diameter, may be added to the short chimney, which can be adapted to any fire-place; by this means the draught augmented prodigiously. It is not essential that this pipe should be tended perpendicularly; on the contrary, it may be placed horizontal, oblique, or proceed in any direction as local conveniences will allow: the waste heat produced by this pipe may be employed to warm the laboratory, or for other purposes. And as this furnace is very heavy, being made of strong hammered sheet iron and lined with fire-bricks within, it is placed upon castors, and strong ring handles are affixed to its sides, so that it may be moved along the floor without much trouble.

The fuel to be used, if an intense heat be wanted, should be coke and charcoal mixt in about equal quantities, and broken into pieces of the size of an egg; for ordinary purposes common coal answers very well. The

ight of this furnace from the grate to the top, is fifteen inches, the s diameter within ten ; the height of the ash-pit to the grate is seven inches ; the arched openings, *cc*, measure four inches by three and a quarter. The fire-bricks with which the body of the furnace is lined, are *læs-laped*, and cemented together by fire lute, to render them not liable to become injured by accidental blows, &c. ; they are, moreover, interlaced with slips of sheet iron, bent twice at right angles, to clamp them together, and to bind the whole lining to the outer case of the furnace. The interval between the brick work and the outer coat of the furnace, which is two inches and a half thick, is filled with charcoal powder and loam, which mixture confines the heat effectually.

THE SAME FURNACE, SMALLER..... 4*L. 14*s. 6*d.***

PACK LEAD TABLE FURNACES, *fig. 1, plate xiii.* 1*L. 12*s.* to 3*L. 13*s.***

THESE furnaces, which are made of two large black lead crucibles, *aa*, joined mouth to mouth, and strengthened with iron hoops, *bb*, are not capable of producing a strong heat, but may be employed for many ordinary purposes. Their size enables them to be used on the table, and to move them to any place where wanted. The fuel to be burnt in these furnaces is charcoal ; they are brittle, and consequently liable to accidents, particularly when hot : *c* is the ash-pot, and the sheet iron chimney.

HICKIN'S PORTABLE BLAST FURNACE, *fig. 2, pl. xiii.* 1*L. 10*s.* to 3*L.**

To excite a sudden heat, and to raise it rapidly to the greatest intensity, nothing can be better calculated than this simple furnace. By the ingenious contrivance of dividing a strong blast of air issuing from a double bellows, and driving it forcibly, first into a small chamber, and thence perpendicularly into a number of converging jets through the centre of the fire place, a most intense heat is rapidly produced, sufficient to melt down cast iron, if the fire be properly managed and the bellows worked with vigour. Coke or cinders, free from clinkers and dust, taken from the common grate when the coal just ceases to blaze, broken into fragments of the size of a walnut, and mix with a little charcoal, form an excellent fuel for this furnace : the fire being first kindled by a few lighted cinders and a small quantity of charcoal or chips of wood. This furnace is composed of three parts, all made of black lead. The lower part, *a*, contains the blast chamber ; to this is fitted the body of the furnace, *b*, which is perforated with blast holes at the bottom ; *c* is the

upper part or doom inverted upon *b*; it serves to concentrate the heat with more efficacy, and to make it reverberate on the bodies exposed to it in *b*; it also protects the eye from the intolerable glare of the fire, when the furnace is in full heat; *d* is a hole to permit the smoke to escape; *f* is a pair of double bellows fixed on the stool; *g*, their handle is lengthened to make them work easier. If a very strong blast be wanted, a heavy weight may be secured to the upper board of the bellows.

**LEWIS'S FORGE FURNACE, fig. 4, plate xiii. .... 17. 12s.**

This furnace consists of two black lead pots placed one within another. The inner or smaller one, *a*, as shewn in the section fig. 4, fits the outer one, *b*, accurately at the brim, where it is secured by lute. It is perforated all round, to admit a blast from the bellows, the nozzle of which is introduced into the hole *c*. *d* shews a crucible placed on its stand in the furnace. This furnace may be used with coke and charcoal for common purposes.

**CRUCIBLE FURNACE, FOR OPEN FIRE, fig. 5 and 6, plate xiii. .... 17. 10s.**

THESE furnaces are made of common black lead crucibles, from twelve to fifteen inches high, perforated at the bottom, and supported by a tripod stand, fig. 8. They are covered with an iron plate, into which two holes are cut; the larger hole admits the sand-pot, fig. 7, for distillation by the retort, as shewn in the drawing. The fuel, which must be charcoal, is put through the smaller hole. The grate, fig. 9, rests on three notches cut at equal distances on the inside of the body of the furnace. These furnaces serve only for moderate heats. Fig. 1, pl. iii, shews the same furnace, provided with an ash-pot made of sheet iron. *aa* is a tube traversing the fire for the decomposition of water, &c. The upper part of the crucible is occasionally perforated to admit air when a cover is put on. The iron ring with three hooks, fig. 10, pl. xiii, is to be sunk into the furnace, and on it may be placed retorts, &c. for distillations by the naked fire.

**ASSAY AND ENAMELLING FURNACE, fig. 2, pl. xvi. .... 8l. 6s.**

This furnace is square, terminating in a truncated open pyramid; *cccc*, doors with handles, with semicircular apertures for inspecting the operation; *aaa*, iron bands fixed with screws; *d*, the ash-pit. The fuel is put in at top.

IMPROVED LAMP FURNACES, *plate xii, fig. 1..... 1l. 1s. to 4l. 4s.*

THE lamp-furnace, as it is perhaps not very properly called, is one of the most convenient means of applying the brilliant flame of an Argand's lamp to the purposes of experimental chemistry. A vast number of chemical operations may be performed with great speed, precision, and expediency, by means of it. Indeed the lamp-furnace may be used for almost every one of the operations of chemistry in the small way, which require a temperature not exceeding a *dull red heat*. The processes of digestion, the sublimation of salts, the solution of earthy and metallic bodies, the concentration of liquids, all the multifarious processes of distillations by the sand-bath, and by the naked fire, the production of gases with the pneumatic apparatus, and even the fusion of earthly minerals with calcines for analysis, may commodiously be accomplished, at a trifling expense, on the table, with the help of this instrument. Besides the heat produced, by the lamp-furnace has the capital advantage of being easily regulated: it may at pleasure be suppressed instantly, or maintained for several hours at a constant and determinate intensity. These advantages will be valued properly by those who know that the most experienced and most attentive chemists meet in practice with frequent accidents, by which both the vessels and the products of the operations are lost for want of power in the proper management of the fire. It is thus also that a number of minute circumstances, which are essential to be known to the student, pass away unnoticed among the furnaces of the regular laboratory, which may be observed when the same process is conducted on the table, and under the immediate eye of the experimenter. *Fig. 1, pl. ix,* exhibits a lamp-furnace in action, connected with an apparatus, to shew the formation of gases, their condensation, and subsequent liberation of caloric, &c.—See *Accum's Chemistry, vol. i, p. 119.*

MUITON'S LAMP-FURNACE *fig. 2, pl. ix..... 2l. 12s. 6d. to 5l. 5s.*LAMP-FURNACE, WITH CONCENTRIC WICKS, *4l. 1s. 6d. to 5l. 15s. 6d.*

In this lamp-furnace a second cylindric wick is added to the common Argand's lamp of the apparatus. These two wicks being concentric, and each of them having an interior and exterior current of air, a double flame is caused, and the power of producing heat is augmented to more than three times that afforded by the ordinary lamp of Argand; a

circumstance which renders the use of this apparatus in the small way, almost equal in effect to a sand-bath. The oil to be burnt in this lamp should be of the very best kind.

**CHEMICAL LAMPS, WITH OR WITHOUT FOUNTAIN RESERVOIR**

*fig. 4, 5, 6, pl. xi . . . . .* 10s. 6d. to 11s. 6d.

**THE SAME, WITH CONCENTRIC WICKS, fig. 2, pl. iv & ix. 2l 2s. to 3l**

All these lamps being flat and low, are very convenient for use. They produce, when charged with fine spermaceti oil, a steady, permanent and easily manageable heat, which may be kept up for many hours.

**SPIRIT LAMPS, fig. 7, pl. ii . . . . .** 7s.

FOR experiments in the small way, which demand a moderate degree of heat, and much neatness in execution, the spirit lamp is an excellent contrivance. The flame of burning spirit of wine being always perfectly clear and free from smoke, produces no soot on the vessel on which it acts. It may easily be made to burn slower or faster, and consequently occasion more or less heat, by merely enlarging or diminishing the surface of the cotton wick upon which the spirit burns ; for as long as the wick is freely supplied with spirit, the flame is precisely of the same strength. The burning of spirit, is besides more clear and elegant than oil ; it gives no unpleasant smell, and does not produce any disagreeable consequence if spilt ; the wick of the lamp is not rendered foul, nor is it scorched or consumed, and the vessel to which the flame is applied does not become obscured by smoke. The expence of the spirit to supply the lamp for experimental purposes, is quite inconsiderable. *a* is the lamp ; *b* the wick holder ; *c* a glass cap, fitted to the lamp by grinding, to prevent the evaporation of the spirit from the surface of the cotton when the lamp is not in use.

**THE SAME, WITH THREE WICKS, DISPOSED IN THE FIGURE OF AN EQUILATERAL TRIANGLE. . . . .** 10s. 6d.

**PORTABLE FORGE OF CAST IRON, WITH DOUBLE BELLOWES BLOWPIPE, AND TALLOW LAMP. . . . .** 12l. 12s.

The smith's forge-hearth is of great convenience to the practical operator of the laboratory ; indeed, the very late discoveries made in physi-

philical chemistry have rendered this machine a particularly necessary appendage to every well regulated laboratory. To obtain the metals from the alkalies and earths, &c. the forge-hearth is very handy. By means of it long tubes may be exposed in a ready way, to an intense heat, whilst the operator, at the same time, is enabled to take them away from the fire quickly, and to replace them instantly at pleasure, a circumstance which cannot be accomplished in any close furnace whatever. For the smelting of metallic ores, the forge is by far the readiest and most commodious contrivance.

The blow-pipe which is adapted to the double bellows of the instrument, is well suited for the purposes of blowing and bending glass, by directing the blast of air through a large skein of cotton, supplied for combustion with melted tallow. Even to kindle a fire quickly, the forge is extremely useful; and by connecting a flexible leather tube to the blast-pipe of the bellows, a stream of air may be introduced into any furnace of the laboratory where a rapid blast is wanted. The small oblong trough attached to the forge-hearth, is convenient to hold hammers, pincers, and other instruments; when filled with water it serves as a bath for tempering iron or steel. As the smoke of the forge fire is very considerable, if common coal be employed, it is adviseable to have a funnel-shaped sheet iron, or brick hood, over the fire, to carry away the smoke into the chimney. If dense coke, or coke and charcoal be used as fuel, the hood is unnecessary.

#### BLOWPIPE TABLE, WITH DOUBLE BELLOWS . . 57. 15s. to 67. 16s.

This simple and useful contrivance for blowing and bending small articles of glass for philosophical purposes, comprises a well finished deal table, underneath of which is fixed a double bellows with a treadle, furnished with a blast-pipe: the latter enables the operator to work the bellows with his foot, whilst both his hands are at liberty. The direction of the blast-pipe being on the front edge of the table where the glass-blower sits, the jet or flame, which is a blunt spear shaped bundle of fire, three or four inches long, is driven away from the artist, so that he is not in the least molested by it. The power of the flame produced by this contrivance is extremely intense; it is sufficient to bring quickly to a red heat a solid mass of glass of the size of a large walnut. The lamp to be used with this blow-pipe is supplied with tallow, heaped upon a large rope of cotton thread, loosely twisted, and completely surrounding it. Indeed, this contrivance affords the most convenient way of heating almost instantaneously, any substance too large to be involved in the common blowpipe flame.

BLOWPIPES OF VARIOUS KINDS, *fig. 1, 2, pl. i., fig. 1, pl. ii., 5s. to 10s. 6d.*BLOWPIPE, WITH DOUBLE BELLOWS . . . . . 5*l. 5s. to 6*l. 6s.**

THE common practice of blowing with the mouth, by means of the blowpipe, though very ready, and requiring an instrument of inconsiderable cost, is not so easy in practice for every one, nor so advantageous in effect as the extrusion of air by means of bellows with double partitions. Besides, the air respired from the lungs being loaded with moisture and contaminated with carbonic acid gas, is very unfit for maintaining combustion; and the act of blowing, even to the most skillful, is attended with fatigue. It requires a confinement of the hands and an awkward position of the head, which considerably diminishes the power as well as the ease of the operator. These disadvantages are obviated by the application of the blowpipe with double bellows. The apparatus, when firmly fixed to a table by means of a clamp, can be worked with the foot placed on the string attached to the pedal of the instrument. The air being then propelled through the pipe, a blast may be kept up with perfect ease, whilst the operator who sits before the lamp, has both his hands and mouth left at liberty.

BLOWPIPE APPARATUS, WITH ADJUSTING CANDLESTICK AND SUPPORT, FOR CHARCOAL, &c. *fig. 1, pl. ii., 2*l. 2s. to 2*l. 1*g.****PEPY'S POCKET BLOWPIPE, *fig. 3, pl. i., 8*s. 6d. to 12*s. 6d.***

THE jet-pipe of this instrument being moveable round a centre, enables the operator to direct the flame of the candle with more precision and convenience in any direction, upon the substance on which it is intended to act. To render the whole more portable, the instrument is divided in the stem, and the two parts being fitted air-tight by grinding, may instantly be slipped together when intended to be used. The flat cylindrical box serves for condensing the moisture of the air expired.

SELF-ACTING SPIRIT BLOWPIPE, *fig. 1, pl. xi., 3*l. 3*s. to 4*l. 4*s.*****

THE action of this blowpipe depends on a rapid stream of alcoholic vapour passing through the flame of a lamp attached to the instrument. It produces a cone of blue fire five or six inches long, accompanied with a hissing noise. The whole apparatus is neatly turned in brass. *a* is a spirit lamp to volatilise the alcohol contained in the globe, *b*; *c* is a safety valve; *d* the jet pipe, to cause the vaporous alcohol to pass through the flame of the spirit lamp.

BLOWPIPE JETS OF PLATINA. .... 5s. to 10s. 6d.

BLOWPIPE FORCEPS, *fig. 7, pl. xv.* ..... 5s. to 7s.

These small forceps, which is entirely made of platina, is very convenient and useful for easily exposing solid materials to the dart of the blowpipe flame. They cannot be melted nor oxidated, nor do they become too hot to be held by the fingers during trial, on account of the bad conducting power of the metal of which they are fabricated. They are also convenient for handling or taking out from the melted fluxes, the small bead of the product.

BLOWPIPE SPOONS OF PLATINA OR SILVER, *fig. 3, pl. xii.* .. 5s. to 10s.

SILVER spoons are best adapted for fusions with glass of borax and alcaline fluxes, for which those made of platina are entirely unfit; they have nevertheless the capital disadvantage that they will only bear a dull heat without risk of melting, whereas spoons of platina are perfectly fusible by the blowpipe flame.

BLOWPIPE LAMPS, WITH LARGE WICKS. .... 5s. to 7s. 6d.

POCKET MINERALOGICAL BLOWPIPE APPARATUS. .... 3l. to 4l.

This small mineralogical case contains Dr. Wollaston's blowpipe, a table magnifier, platina foil, a blowpipe forceps, two bottles of fluxes, a steel cover, jet tubes, and the most essential re-agents necessary for the immediate examination of minerals. It affords a convenient way for examining the nature or composition of any mineral, though the actual quantities of the substances discovered are too minute to enable the operator to ascertain their relative proportions.

PLATINA BLOWPIPE FOIL. ....

This foil is very serviceable for exposing to the flame of the blowpipe such substances as readily split, and are dispersed when heated by the blowpipe dart on charcoal, or when held by the forceps in the spoon. Any substance, wrapped up in a piece of this foil, may readily be kept steady during trial.

BLOWPIPE BLADDER, WITH BELL-GLASS, STOP-COCK, &c.

1l. 16s. to 2l. 12s. 6d.

THIS contrivance is admirably well adapted for exciting the highest possible degree of heat that artificial fire can produce, by directing a continu-

nued stream of oxygen gas on a piece of ignited charcoal, or on the flame of a candle. The heat produced on a piece of ignited charcoal urged by a stream of oxygen gas from the bladder, which may be compressed under the arm of the operator, to give considerable velocity to the blast, is so intense as to fuse in a few minutes into a mass, pieces of platina, or fragments of the purest rock-crystal.

This apparatus is also well calculated for proving the increase of weight of bodies during combustion, by directing a current of oxygen gas by means of the jet-pipe on a weighed quantity of copper or iron wire kept ignited in the bowl of a common tobacco pipe or small crucible. The reduction of metallic oxids, and the de-oxidation of binary acids, &c. may be exhibited by means of it, in the most commodious way.

#### BURNING LENSES, AND CONCAVE MIRRORS. .... 5s. to 10s.

The application of heat, produced by collecting into a focus the solar rays, is by far the best contrivance adapted for the most delicate experiments of chemistry. This mode of producing heat admits of being applied under all possible circumstances. However complicated the auxiliary arrangement of the apparatus required for the views of the experiment may be, the most intense solar focus may be directed on the minutest quantity of materials, and no cause of error can influence the result of the experiment, as may always happen from the heat produced by burning fuel. Besides, the focus of the solar beam collected by the lens, or reflected by the mirror, may be transmitted with the greatest nicety through any glass vessel containing the object of the experiment.

Concave mirrors produce rather more effect than convex glasses of the same diameter; but as the direction of the reflected rays is necessarily from below upwards, the use of them is rendered less commodious for the purposes of chemistry.

#### STEAM-BOILERS, *fig. 10, pl. ix.* ..... 10l. 10s. to 15l. 15s.

This apparatus is extremely well adapted for exhibiting in a lecture-room, the modes of warming by steam the water of baths, the boiling of water, and the heating of apartments by the same agency, and many facts in illustration of the general doctrine of latent caloric, and its useful application in the arts.—See *Henry's Chemistry*, vol. i., p. 141, 143, &c. *a* is a copper boiler; *b* a thermometer fixed into the boiler; *c* the pipe; *d* a glass vessel containing water to be heated by steam; *fig. 11* and *12*, vessels for evaporating fluids by steam, &c.

CONCAVE METALLIC MIRRORS, WITH STANDS, FOR RENDERING SENSIBLE THE REFLECTION OF RADIANT HEAT, UNACCOMPANIED BY LIGHT, *fig. 2, pl. vii.* . . . . 2*l.* 15*s.* to 10*l.* 10*s.*

THE Emissaries are chiefly contrived to shew that hot bodies, and such as are only moderately warm, project from their surface, in the form of right lines, invisible rays of heat, which are capable of raising the temperature of substances by which they are intercepted, and that comparatively cold bodies receive, and absorb the invisible radiant calorific matter, or *caloriferous rays*; *e.g.*, two concave mirrors are placed opposite to one another at a distance of many feet, the bulb of a thermometer is introduced between them, and a glass matress, filled with boiling water, or an iron bullet, heated so as to be just not visible in the dark, is placed in the focus of the other. A substance is radiated from the matress or iron bullet; it passes with incalculable velocity through the air; is reflected from the mirrors, and concentrated according to the laws of light, and then influences the thermometer, according to the degree of its concentration.

ODS, OF DIFFERENT METALS, WITH IRON HEATER, &c.

14.1s to 14.10s, 6d.

For illustrating the unequal propagation of heat, or comparative conducting power of different bodies with regard to caloric.

COLT HEADS, OF EQUAL CAPACITY, FOR EXHIBITING THE  
RELATIVE DEGREES OF EXPANSION PRODUCED IN DIFFERENT LIQUIDES BY SIMILAR ELEVATIONS OF TEMPERATURE.

THESE small globes with slender necks, when filled with different fluids or instance, with mercury, alcohol, or water; to a certain point in the em, show, when immersed into hot water, that different liquids expand differently by equal quantities of caloric, or at equal elevations of temperature, and that the dilatibility of different bodies is inversely as their melting point.

AVOISIERE'S CALORIMETER *fig. 3, pl. vii* .... 10<sup>1</sup> to 12<sup>1</sup> 12<sup>2</sup>

This elegant machine being large, and all its parts simple and conspicuous, is well calculated for a public lecture-room. From some experiments made by Mr. Wedgwood, it has been doubted whether it can afford accurate results. (*Phil. Trans.*, vol. lxxiv, p. 376.) These objections, however plausible as they may appear, are easily obviated by operating

only at, or a little above 32°. Indeed the nearer the temperature of the atmosphere in which the experiment is conducted, approaches to 32°, the more accurate will be the result. The observations of Mr. Wedgwood may nevertheless be held out as a caution, but they certainly do not invalidate the accuracy of the machine. *a* exhibits a perspective view of the apparatus; *b* its perpendicular section.—The mode of operating with this apparatus may be seen in Thompson's Chemistry, vol. pl. I, fig. II.

**LESLIE'S APPARATUS FOR ASCERTAINING THE RELATIVE QUANTITIES OF SPECIFIC CALORIC, WHICH EQUAL BULK OR WEIGHT OF BODIES CONTAIN AT EQUAL TEMPERATURES.....** 12. 1s. to 12. 10s. 6d.

A very simple contrivance for determining in an easy manner, the specific calorie of bodies, whether solids or fluids, by pointing out the relative celerity with which different bodies cool a certain number of degrees when compared with a standard body similarly situated. And although the result afforded by means of this apparatus indicate only the quantities of specific caloric contained in equal bulk of bodies; yet if according to Mr. Leslie, they be divided by their specific gravities, the quotient gives the respective shares of specific caloric contained in the equivalent expressions of equal weight of bodies.

**MERCURIAL THERMOMETERS; the Scale-board Wood, Metal, &c  
Ivory .....** 10s. 6d. to 12. 1s.

**MERCURIAL THERMOMETERS, WITH NAKED BULB, fig. 9, pl. viii**  
10s. 6d. to 12. 1s.

**MEDICAL THERMOMETERS .....** 10s. 6d. to 12. 1s.

**POCKET MERCURIAL THERMOMETERS .....** 12s. 6d. to 12. 1s.

THESE thermometers are extremely sensible, being made with very small balls, and tubes of extremely narrow bores.

**CHEMICAL THERMOMETERS, fig. 10. pl. iv,....** 12. 5s. to 12. 11s. 6d.

THESE thermometers exhibit the entire range of thermometrical temperature, from the freezing, to the boiling point of mercury. They are furnished with a joint or sliding hinge, the lower part of the scale-boar-

may therefore be made to fall back, to leave the bulb and part of the tube bare, so that it may safely be immersed into acids or other corrosive fluids, without occasioning any injury to the board on which the scale is delineated.

**THE SAME, IVORY SCALE . . . . . 17. 12s. 6d. to 21. 2s.**

THE scale of degrees being engraved on a slip of ivory placed in the cross direction of its organic structure, against the longitudinal fibres of the box-wood scale-board in which it is let into, renders the instrument less liable to bend, or become otherwise altered by moisture, as must necessarily happen to all thermometers on which the scale-board is of wood.

**HEMICAL THERMOMETERS, WHICH PERMIT THE WHOLE OF THE MERCURIAL COLUMN TO BE IMMERSED WITHOUT THE SCALE . . . . . 17. 11s. 6d. to 21. 2s.**

THE tube in this instrument is made to slide up and down upon the scale, and is adjustable at any height, by means of a moveable screw, which presses against the scale plate. The graduation, which consists of two sets of figures, is so arranged that the temperature of any fluid may be determined by inspecting the scale, while the tube at the same time remains immersed in the fluid.

**SPRIT THERMOMETERS . . . . . 17. 5s. to 17. 16s. 6d.**

THESE thermometers being filled with alcohol, a fluid which does not freeze, are best adapted to the measurement of very low temperatures at which quicksilver would freeze, but they are unfit for measuring temperatures above 180 Fahr.

**SELF-REGISTERING THERMOMETERS . . . . . 17. 10s. to 21. 2s.**

THIS ingenious contrivance marks the degrees of the greatest intensity of heat and cold from one time of observation to another during the absence of the observer.

**BOTANICAL THERMOMETERS . . . . . 15s. to 17. 10s.**

**BR THERMOMETERS, fig. 14, 15, 16, pl. ix, and fig. 2, pl. xiv, 5s. to 10s. 6d.**

THIS thermometer indicates the smallest degree of temperature; and on this account it is with much advantage employed in the most delicate

experiments in illustration of the reflection and radiation of caloric, and occasionally also for other purposes, although it is otherwise a very inaccurate instrument, and liable to many objections when compared with the mercurial thermometer. Its utility consists in the great amount of the expansion of air which, by a given elevation of temperature, is increased in bulk above twenty times more than mercury, and hence it detects minute changes of temperature which the mercurial thermometer cannot discover.

#### LESLIE'S DIFFERENTIAL THERMOMETER, *fig. 1, pl. iv. .... 1l. 1s.*

This instrument, which is not at all influenced by any variation of temperature in the surrounding medium, is peculiarly calculated for experiments on radiant caloric: it combines great delicacy with accuracy. The differential thermometer, as its name expresses, announces not the absolute degree of heat, but the difference (when any exists) between two given spots where the thermometer is made to act. A moment's attention to the construction of the instrument, which is in fact a double air thermometer, separated by a portion of intercluded fluid, will shew that it indicates only the difference of heat of two contiguous spots. As long as the elasticity of the air in one leg is equal to that in the other, the air contained in both balls will have the same elasticity, and the liquor in each tube or leg will be equally pressed on in opposite directions, and will remain stationary at a certain height. If the instrument, for instance, be introduced either into a warmer or colder atmosphere, the temperature of both balls will be equally affected; the volume of air in each will be equally expanded or contracted; and hence the liquor will still remain stationary. But, if one of the balls be more heated or cooled than the other, this equilibrium will be subverted, the superior elasticity of the confined air of the ball, which is exposed to a warmer air, will drive the interposed liquor forwards, and make it rise in the tube connected with the ball which is at the lower temperature, and of course fall in the other; and hence the instrument is calculated to point out the *difference* of temperature in the corresponding balls; this it will do with peculiar nicety.

#### FERGUSON'S IMPROVED PYROMETER ..... 5l. 5s. to 7l. 7s.

This pyrometer is well calculated for exhibiting the expansion of different metals at equal temperatures, without pretending to determine the value of their relative admeasurment.

COCKET CONDENSING SYRINGES FOR PRODUCING FIRE BY  
THE RAPID MECHANICAL COMPRESSION OF COMMON  
AIR..... 10s. 6d. to 11. 5s.

This little syringe, which is only four inches long and three-fourths of an inch in diameter, is a useful instrument for showing the evolution of heat, by the sudden compression of air. By a single stroke of the piston, a small quantity of tinder, or *amadou*, previously affixed to its lower extremity, may thus be instantly set on fire.

FREEZING APPARATUS FOR EXPERIMENTS ON ARTIFICIAL  
COLD, *fig. 4, pl. iv* ..... 7s. 6d. to 10s. 6d.

This is a convenient contrivance for exhibiting, at a cheap rate, the congelation of mercury during the heat of the summer.

HENRY'S IMPROVED DITTO..... 2l. 2s. to 3l. 3s.

PEPPYS'S FREEZING APPARATUS, *fig. 13, pl. ix.* 3l. 13s. 6d. to 4l. 14. 6d.

A more elegant contrivance for experiments on artificial cold, well adapted for public exhibition.—*Accum's Chemistry, vol. ii, pl. ii. fig. 5.*

DISTILLATORY APPARATUS FOR ILLUSTRATING THE PRO-  
DUCTION OF GASES AND THEIR CONDENSATION, *fig. 6, pl. ii,*  
3l. 3s. to 3l. 13s. 6d.

This arrangement is contrived to show that caloric is absorbed during the evolution of gases, without occasioning an increase of temperature; and liberated again as sensible heat when the gas returns to the solid state.

PNEUMATIC TROUGHS, ADAPTED FOR THE TABLE, *fig. 9, 10, 11,*  
*pl. xi.*..... 10s. 6d. to 11. 1s.

THESE troughs, which may be had either with square sliding shelves, round or oblong, are very light when empty, and convenient for most private operations on gases.

LARGE PNEUMATIC CISTERNS, OF WOOD OR JAPANNED IRON,  
1l. 1s. to 4l. 4s.

ACCUM'S PNEUMATIC TABLE.....4*l.* 14*s.* 6*d.* to 5*l.* 5*s.*

For collecting and transferring gases, this table, it is presumed, will be found more commodious than the pneumatic reservoir in common use. It obviates the necessity of transferring the jars out of the water, when filled with gas; and consequently the danger of suffering part of the air to escape is avoided. It enables the operator to fill vessels of almost any size, without obliging him to immerse them previously into a deeper reservoir, from whence they must be carried upon a plate into the trough where they are to be filled with the gas. Thus, the inconvenience of having either too much or too little water, and the continual emptying and filling the reservoir as the level of the water rises or falls, is avoided. Besides, the vessel cannot be overset by the pressure of the fluid, the height of which often rapidly increases in the trough of the common construction. When large quantities of gases are required, as in public lectures, or when a number of experiments are intended to succeed each other quickly, this table has been found exceedingly useful. The operator is not restrained for room in the management of his experiments; he is not induced to encroach upon the surrounding furniture; and a deal of disagreeable dabbling in water is avoided.

FLEXIBLE METAL CONDUCTING TUBES, WITH OR WITHOUT  
BRASS JOINT, SO AS TO BE READILY ELONGATED AT  
PLEASURE, *per Foot* ..... 1*s.* 6*d.*

THESE tubes are useful for conveying gas in any direction and to any moderate distance. Separate lengths of them may be connected together instantly, and adapted to the retort, gasometer, or other vessel from which gas proceeds. In fig. 6, *aa*, *pl.* xv, the use of these tubes is shewn, by connecting the air-holders, *bb*, with the gasometer, *c*.

SHALLOW EARTHENWARE DISHES FOR CONVEYING VESSELS,  
FILLED WITH GAS, IN AND OUT OF THE PNEUMATIC  
TROUGH, *fig.* 11, *pl.* iv, and *fig.* 3, 4, 5, *letters* *aaa*, *pl.* ix,  
1*s.* to 3*s.* 6*d.*IMPROVED PNEUMATIC MERCURIAL TROUGHS, WITH SLID-  
ING SHELVES, *fig.* 6, *pl.* ix.....1*l.* 5*s.* to 2*l.* 10*s.*

THIS is the most simple and economical contrivance for operating on such gases as cannot be collected in the water trough. It economises

tom, and consequently mercury; for only one of the inner sides is excavated, and serves as a reservoir, whilst the other is destined as a stage or shelf for supporting the cylinders to be filled with gas. The sliding shelf or solid block, which is moveable backwards and forwards within the reservoir, is excavated to receive the beak of the retort or vessel from which gas issues. *a* is a tray adapted to the trough, to collect any mercury that may happen to be spilt. The quantity of mercury necessary to fill this trough is 20*lb.*

CAST IRON MERCURIAL TROUGHS, CASED WITH MAHOGANY WOOD, *fig. 7, pl. ix.*.....

This trough is calculated for public exhibition. It requires 40*lb.* of mercury. *Fig. 8, pl. ix.*, shews a transverse section of the trough, with retort and air jar.

CYLINDRICAL AIR JARS, PLAIN, WITH THE MARGIN OF THE OPEN END GROUND SMOOTH AND ADAPTED TO THE MERCURIAL TROUGH ..... 1*s. 6d.* to 10*s. 6d.*

THE SAME, GRADUATED INTO CUBIC INCHES AND DECIMAL PARTS..... 2*s. 6d.* to 18*s.*

GAZOMETERS, OF COMMON CONSTRUCTION, MADE OF JAPANNED IRON, *fig. 1, pl. viii.* ..... 4*l. 4s.* to 10*l. 10s.*

The extended application of the gazometer in the practice of pneumatic chemistry is sufficiently known. Besides the ordinary purposes to which it is applied, namely, to enable the chemist to collect and to preserve large quantities of gases, this machine may be used as an excellent blowpipe, to keep up for a long time an uninterrupted blast of air; the velocity of the stream may be increased or diminished at pleasure, by the pressure which the operator applies to the bell, *b*, of the machine. In substituting oxygen gas for common air in the gazometer, an opportunity is given to excite the most intense heat that combustion can produce. As breathing gases, the gazometer is the most convenient instrument.

THE SAME, ON A BETTER AND MORE ELEGANT PLAN,

5*l. 5s.* to 10*l. 10s.*

CUM'S IMPROVED GAZOMETER, WITH GLASS BELL, &c., *fig. 2, pl. viii.* ..... 6*l. 6s.* to 10*l. 10s.*

THE SAME, LARGEST SIZE, WITH ADDITIONAL AIR-HOLDERS,  
*fig. 6, pl. xv.* ..... 15*l.* 15*s.*

PEPY'S MERCURIAL GAZOMETER, *fig. 11, pl. viii.* ..... 10*l.* 10*s.*

FOR experiments on gases, which require much accuracy, and which cannot be performed over water, this gazometer, which is made of cast iron, is extremely useful. The experiments may be performed by mean of it on a tolerable large scale, although the necessary quantity of mercury to fill the gazometer, &c. is comparatively small. The apparatus however, is too costly and too easily put out of order to be accepted with welcome among the cultivators of chemical science.

THE SAME, WITH TRANSFERS, *fig. 12, pl. viii, ibid.* ..... 12*l.* 12*s.*

GLOBES (*fig. 2<sup>1</sup>*) FOR WEIGHING GASES, EXHAUSTING SYRINGE  
 (13), CAOUTCHOUC BOTTLES, (*fig. 14*), &c. ..... 14*l.* 14*s.*

CLAYFIELD'S MERCURIAL GAZOMETER, *fig. 2 & 3, pl. xv.* ..... 16*l.* 16*s.*

IN this gazometer the source of fallacy, arising from the influence of pressure upon the gas within the gazometer, as must often happen when the mercury which confines the gas within the vessel is not on a level with that without, is ingeniously prevented.

RETORTS, WITH LONG NECKS, FOR PROCURING GASES,  
 1*s.* 6*d.* to 2*s.*

THE slender narrow neck of these retorts, as no vapour is to be condensed, renders the disengaged gas less liable to become contaminated with atmospheric air, as must be the case when the ordinary kinds of retorts are used, of which the necks are very capacious.

APPARATUS FOR MAKING ARTIFICIAL MINERAL WATERS,  
 30*l.* to 60*l.*

This machine is well adapted for manufacturing, on a large scale, the brisk foaming mineral waters, viz. soda water, seltzer water, &c.

THE SAME APPARATUS, ON A SMALL SCALE, AND LESS PERFECT ..... 18*l.* to 20*l.*

THE SAME, AS SHEWN, *fig. 1, pl. xv.* ..... 10*l.* 10*s.*

NOPE'S EUDIOMETER, *fig. 8, pl. xi.* ..... 10s. 6d.

LEPY'S COMPOUND EUDIOMETER ..... 4l. 14s. 6d.

THIS is a very ingenious contrivance, and may be of great service to those gentlemen whose fortune permits them to adopt the use of such physico-mechanical conveniences in their chemical practice. The operative chemist may object to it on account of its complex structure, and as tending to render unnecessary that manual dexterity in the use of simple instruments, which it is of the utmost importance to acquire.

PAVY'S EUDIOMETER ..... 10s. 6d.

TRIESTLEY'S EUDIOMETER, *fig. 17, pl. viii.* ..... 10s. 6d. to 1l. 10s.

MAGS OF VARNISHED SILK, FOR INHALING OXIGEN AND OTHER GASES ..... 10s. 6d. to 2l. 2s.

BERTHOLET'S POCKET EUDIOMETER ..... 10s. 6d. to 15s.

This eudiometer is at once simple and effectual for analysing the air of the atmosphere. It is not liable to those errors which attend the usual processes of eudiometry. The only correction necessary to be made in the application of this eudiometer, is to deduct from the residual air  $\frac{1}{40}$  of its bulk, and to add this to the volume of oxygen gas indicated by the process. The size of this instrument renders it convenient to be carried in the pocket. The process of employing it for analysing atmospheric air requires only about one hour.

GUN-BARREL APPARATUS, WITH FLEXIBLE METAL CONDUCTING TUBE, FITTED BY GRINDING ..... 12s. to 18s.

THIS apparatus is contrived for shewing the decomposition of water, or for procuring hydrogen or carburetted hydrogen gas, by causing steam to pass over coal or charcoal. The inside of the barrel should be scraped from time to time, and the outside coated with loam, to prevent it from sealing when in the fire.

NICHOLSON'S GRAVIMETER ..... 4l. 14s. 6d.

IT does not appear that a better method for the specific gravities, particularly for the use of the chemist, need be wished for. This instrument determines the specific weight of both solids and fluids in an easy and expeditious way. It requires no address in using it, and its accuracy

reaches to the fifth figure of the decimal, water being taken as unity.

**ANVILS FOR THE TABLE, FIXED IN A WOODEN STAND, fig. , pl. i .....** 5s.

**GOGLERS AND MASKS, TO DEFEND THE EYES AGAINST ACCIDENTS IN CHEMICAL OPERATIONS .....** 8s. 6d.

**BARS OF ZINC, COPPER, TIN, AND IRON, FOR PRECIPITATING CYLINDERS OF THE SAME METALS, per Set, 4s. to 6s.**

**FUMIGATING APPARATUS. ....** 12s.

**PORTABLE DISINFECTING, OR PRESERVATIVE VIALS, WITH DIRECTIONS FOR USE.....** 10s. 6d. to 12s. 6d.

This is a very useful apparatus, worthy the attention of every medical gentleman, and commissary of a board of health. It is recommended by the Royal College of Physicians of Edinburgh as the best preservative against *miasmata*. It is useful to purify the air in the chambers of the sick, in places which are infected with bad smells arising from drains, sewers, cess-pools, and sinks of all kinds; sleeping rooms, hospitals, prisons; and, indeed, in every place where air becomes vitiated, either from morbid or putrid miasmata, or other causes. The following lines are copied from the "Retropect," vol. i, page 30:—"Besides the situations where the apparatus is of use, it would also be so extremely serviceable in ships, that it is probable no captain would go any distant voyage without one, if its utility were explained to him, in preventing infection of all sorts, not excepted that of the yellow fever."—The apparatus acts for many months with a single charge.

**THE SAME APPARATUS, FOR LARGE WARDS OF HOSPITALS, PRISONS, &c. . . . .** 1l. 1s. to 1l. 10s.

**GAS-BOTTLES, WITH RE-CURVED GLASS TUBES, FITTED BY GRINDING, fig. 6, pl. xiv .....** 2s. 6d. to 7s. 6d.

THESE bottles are commodious when the production of the elastic fluid is not rapid, and the quantity demanded only moderately small. The bottom part of the vessel being made round, and blown thin, renders them not liable to crack by the application of a gentle heat.

**THE SAME, TUBULATED, fig. 21, pl. xi .....** 5s. 6d. to 15s. 6d.

CAST IRON RETORTS, *fig. 3, pl. iii* ..... . . . . . 18s.

THESE are intended for obtaining such gases as cannot be disengaged without exposing the materials from which they are to be produced to a red heat.

THE SAME, WITH FLEXIBLE METAL CONDUCTING TUBES,  
WITH BRASS JOINT, TO FIT IRON RETORTS, 1*l.* to 1*l. 11s. 6d.*

FLASKS WITH BENT TUBES, FOR EXTRICATING GASES,  
*fig. 12, pl. xi* ..... . . . . . 2s. to 5s.

FLASKS, MOUNTED WITH STOP-COCKS, FOR WEIGHING  
GASES, *fig. 5, pl. i* ..... . . . . . 12s. 6d.

HIGH-STRENGTH IRON GAS RETORTS, IN SIZES, *fig. 3, pl. x,*  
1*l.* 1s. to 3*l.* 3s.

THESE retorts, as well as those of cast iron, are by far the best instruments for obtaining, in a cheap manner, all those gases which require, for their production, a red heat. They may be used with a common coke.

SCCUM'S APPARATUS FOR OBTAINING FLUORIC ACID, 1*l. 1s.*

LEADEN CONDUCTING TUBES FOR DITTO, 1s. per Foot.

LEADEN BOTTLES FOR PRESERVING FLUORIC ACID,  
5s. 6d. to 10s. 6d.

LEAD-GLASSES, MOUNTED WITH BRASS CAPS AND STOP-COCK, &c. *fig. 1 a, pl. xiv* ..... . . . . . 10s. to 2*l. 13s. 6d.*

THIS is one of the most useful apparatus in the whole collection of chemical instruments for operating on gases, on account of the vast number of purposes to which it may be applied. The cultivators of chemistry are too well acquainted with the extended application of this apparatus, to render any further observation concerning it necessary.

THE SAME, WITH BEST KIND OF STOP-COCKS, CONNECTING PIECE, &c. AND GLOBE FOR WEIGHING GASES, *fig. 1, a,b,c, pl. xiv* ..... . . . . . 2*l. 2s.* to 8*l. 3s.*

- THE SAME, WITH BLOWPIPE, JET, AND TOBACCO PIPE, FOR THROWING UP SOAP-BUBBLES INFLATED WITH INFLAMMABLE GAS, &c. .... 2*l.* 12*s.* to 3*l.* 3*s.*
- BELL-SHAPED RECEIVERS, VARIOUS, FOR COLLECTING GASES, *fig.* 22, 23, 24, *pl.* xi, and *fig.* 3, 4, 5, *pl.* ix., 2*s.* 6*d.* to 1*s.*
- THE SAME, DIVIDED INTO CUBIC INCHES .... 4*s.* 6*d.* to 1*l.* 1*s.*
- BRASS WIRE STAND, WITH LEADEN FOOT .... 3*s.* 6*d.*
- This stand is useful for supporting above the surface of water within jar, any substance intended to be exposed to the action of a gaseous fluid; it takes but little room, stands very steadily, and is easily adapted to any figure or height.
- AIR-HOLDERS, OF JAPANNED IRON, *fig.* 15, *pl.* viii., 1*l.* 1*s.* to 1*l.* 10*s.*
- This is an ingenious machine for collecting and preserving large quantities of gases, and for transferring them into bladders, bottles, &c. \*
- THE SAME, WITH PNEUMATIC CISTERNS AND HYDROSTATIC FUNNEL ..... 2*l.* 12*s.* 6*d.*
- This apparatus is well contrived for exhibiting the combustion of inflammable bodies in oxygen gas. By means of the hydrostatic funnel, may also be made to act as an excellent blowpipe.
- REID'S AIR HOLDER, *fig.* 16, *pl.* viii ..... 14*s.* to 1*l.* 5*s.*
- CYLINDRICAL GLASS JARS, IN SIZES, FOR COLLECTING GASES, *fig.* 2, *pl.* xiv, and *fig.* 18, *pl.* ix. .... 4*s.* to 1*s.*
- THE SAME, DIVIDED INTO CUBIC INCHES AND DECIMAL PARTS ..... 5*s.* to 1*l.* 10*s.*
- DEFLAGRATING JARS, FOR THE COMBUSTION OF INFLAMMABLE BODIES IN OXYGEN GAS, *fig.* 5, *pl.* ix. .... 3*s.* 6*d.* to 1*s.*
- DEFLAGRATING LADLES, OF COPPER, *fig.* 13, *pl.* i. .... 9*d.* to 1*s.* 6*d.*

- CIRCULAR PIECES OF METAL PLATES, GROUND FLAT, TO CLOSE THE MOUTH OF DEFLAGRATING JARS ..... 2s. 6d.
- GROUND PLATES OF GLASS FOR DITTO ..... 2s. 6d.
- LARGE BLADDERS, MOUNTED WITH STOP-COCK AND CONNECTING PIECE, FOR TRANSFERRING GASES, &c. *fig. 18, pl. viii.* ..... 12s. to 15s.
- NOTH'S APPARATUS FOR IMPREGNATING FLUIDS WITH GASES, *fig. 4, pl. vi.* .....
- HIGHT'S IMPROVED VERTICAL DITTO, *fig. 9, pl. iv.*, 3*l. 3s. to 4*l. 14*s. 6*d.****
- This is an ingenious and simple modification of Nooth's apparatus, well adapted for practical utility.
- IMPROVED WOULF'S APPARATUS, WHICH REQUIRES NO LUTTING, *fig. 3, pl. vi.* ..... 3*l. 13*s. 6*d. to 4*l. 14*s. 6*d.******
- MILTON'S APPARATUS FOR IMPREGNATING FLUIDS WITH GASES, *fig. 3, pl. vi.* ..... 3*l. to 4*l. 6*s.***
- Of all the contrivances that have been recommended for impregnating fluids with gases, this undoubtedly is the most simple and convenient, fully answers the purpose, and requires no address in using it. Besides the parts of the apparatus are simple, and not readily put out of order, liable to accident.
- APPARATUS FOR PRODUCING GAS LIGHTS, FOR THE PURPOSES OF ILLUMINATION, ..... 20*l. to 50*l.**
- This apparatus is adapted for public exhibition.
- GAS LAMP, WITH MOVEABLE TUBES ..... 12*s. 6*d.**
- BRIDEN PIPES,  $\frac{1}{2}$  INCH DIAMETER, FOR CONVEYING GAS TO ANY DISTANCE, *per Foot* ..... 10*d.*
- THIBERTSON'S APPARATUS FOR SHOWING THE FORMATION OF WATER BY THE SLOW COMBUSTION OF HIDROGEN GAS IN AN ATMOSPHERE OF OXIGEN, 7*l. 17*s. 6*d. to 10*l. 10*s.*****

**APPARATUS FOR EXHIBITING THE DIMINUTION OF OXIGEN AND HIDROGEN GAS DURING THE UNION OF THEIR BASES, BY SLOW COMBUSTION, fig. 9, pl. ix, a.....**

**THE SAME APPARATUS, WITH PNEUMATIC CISTERN, BLADDER, AND FLEXIBLE TUBE, fig. 9, pl. ix i. 1l. 10s. 6d. to 2l. 2s.**

**APPARATUS FOR EXHIBITING THE FORMATION OF WATER FROM THE UNION OF THEIR BASES, BY THE RAPID COMBUSTION OF OXIGEN AND HIDROGEN GAS ..... 18**

This is a simple and elegant contrivance for exhibiting the composition of water in the small way, and best calculated to afford accurate results.

**WOULF'S APPARATUS, CONSISTING OF THREE-NECKED BOTTLES, MOUNTED WITH TUBULATED RETORT AND RECEIVER, fig. 2, pl. x, a, b, c, d, e ..... 1l. 11s. 6d. to 3l. 3s.**

**THE SAME APPARATUS, WITH A SERIES OF FIVE TWO-NECKED BOTTLES, WITH WELTER'S TUBES OF SAFETY, TWO-NECKED GLOBULAR RECEIVER, AND RETORT WITH HYDROSTATIC TUNNEL AND ADAPTER, fig. 5, a, b, c, d, e  
2l. 15s. to 4l. 4s.**

**WOULF'S APPARATUS, CONSISTING OF ONE THREE-NECKED BOTTLE, TUBULATED RECEIVER, AND WELTER'S TUBE OF SAFETY, fig. 19, pl. ix..... 1l.**

**MURRAY'S APPARATUS FOR IMPREGNATING FLUIDS WITH GASES, CONSISTING OF ONE OR MORE TWO-NECKED BOTTLES, fig. 1 and 2, pl. vi ..... 2l. 2s. to 3l. 3s.**

**PEPY'S APPARATUS FOR IMPREGNATING FLUIDS WITH GASES, fig. 1, pl. xiv ..... 4l. 14s. 6d.**

**BURKITTE'S APPARATUS FOR SATURATING FLUIDS WITH GASES, fig. 11, pl. xii ..... 3l. 13s. 6d.**

DETONATING TUBES, MOUNTED WITH PLATINA OR BRASS CONDUCTORS, FOR EXPLDING INFAMMABLE GASES, AND FOR TAKING THE ELECTRIC SPARK IN CONFINED QUANTITIES OF AERIFORM FLUIDS, *fig. 24, pl. xi, and fig. 17, pl. ix* ..... 10s. 6d. to 1L 10s.

THIS graduated tube is also employed for ascertaining the proportion oxygen gas in any other gaseous fluid: it then constitutes Volti's eudiometer for analysing atmospheric air, viz. by submitting to trial, and fusing by the electric spark, 60 parts of hydrogen with 100 of atmospheric air. This process of eudiometry has the great advantage of not requiring any correction for variations of temperature or barometrical pressure.

IRON STAND FOR SUPPORTING DETONATING TUBES IN THE PNEUMATIC TROUGH ..... 1L 1s. to 1L 11s. 6d.

By means of this stand the inconveniences of spilling mercury, or bursting the tube, which attend the explosion of inflammable gases, when fed by electricity in the mercurial trough, is avoided, and much larger quantities of gases may be detonated by means of it with safety, than can be done in the ordinary way. The force of the explosion exerted against the mercury or water in which the detonating tube is immersed, comes greatly diminished by the action of the steel spring of the stand, so that the operation of it is rendered more convenient and safe.

APPARATUS FOR PRODUCING NITROUS ACID FROM NITROUS GAS AND OXYGEN, AND ALSO FOR ILLUSTRATING THE PERMANENT ELASTIC OR GASEOUS STATE OF NITROUS ACID AT COMMON TEMPERATURES ..... 1L 1s. to 2L 10s.

This apparatus is particularly well calculated to exhibit, in a public audience-room, the facts which it is intended to illustrate, its parts being simple and easily managed.

CYLINDRICAL GLASS TUBES, OPEN AT ONE END AND CLOSED AT THE OTHER, GRADUATED INTO CUBIC INCHES AND DECIMAL PARTS, DIFFERENT SIZES, *fig. 8, 9, 10, pl. vi,*

the weighing of gases is troublesome in extraction, and requires a double balance, and also an air-pump, to extract the vapour, chemise, in the

ordinary way of business, measure the volume of gases in tubes of the kind, and find their weights by reference to the tables of their specific gravities, which have been constructed for that purpose.

**DOUBLE BARRELLED TABLE AIR-PUMPS, SMALL SIZE, WITH GAUGE-PLATE AND SYPHON-GAUGE.....** 5*l.* to 10*l.*

**THE SAME CONSTRUCTION, LARGER, AND EXHAUSTING MORE POWERFULLY.....** 10*l.* 10*s.* to 30*l.*

**THE SAME, FOR CHEMICAL PURPOSES.....** 10*l.* to 20*l.*

**INFLAMMABLE AIR LAMPS .....** 6*l.*

**GLASS RETORTS, PLAIN, IN SIZES, FROM  $\frac{1}{4}$  OF A PINT CAPACITY TO SIX GALLONS.....** 1*s.* to 1*l.*

**GLOBULAR RECEIVERS, PLAIN, OF DIFFERENT SIZES..** 1*s.* to 1*l.*

**ADOPTERS OF GLASS AND OF EARTHENWARE, STRAIGHT OR CROOKED, fig. 6, pl. i, fig. 9 and 10, pl. xiv .....** 1*s.* 6*d.* to 1*l.*

These vessels are useful to elongate the necks of retorts, to increase the distance between them and the receivers in the process of distillation, and to promote the condensation of the vaporous product, particularly in such cases where it is not readily condensable.

**TUBULATED RETORTS AND RECEIVERS, IN SIZES..** 2*s.* 6*d.* to 1*l.*

**RETORTS AND RECEIVERS, FITTED AIR-TIGHT BY GRINDING WHICH REQUIRE NO LUTING.....** 5*s.* to 1*l.*

**RETORTS, MOUNTED WITH HIDROSTATIC FUNNEL, fig. 23, pl. viii .....**

**BALLOON RECEIVERS, PLAIN AND TUBULATED, fig. 5, and pl. xiv,.....** 1*s.* 6*d.* to 1*l.*

**HOOPS FOR SUPPORTING FLASKS, RETORTS.....** 6*d.* to 2*s.*

**IRON RINGS TO FIT UNIVERSAL AND OTHER FURNACES, fig. 19, pl. iii, per set.....** 5*s.* to 10*s.*

IRON RINGS FOR CUTTING THE NECKS OF RETORTS, &c. *fig. 12.*  
*pl. v.* ..... 2s. 6d. to 7s.

BRTHENWARE RETORTS, PLAIN OR TUBULATED, IN SIZES,  
*2s. 6d. to 7s.*

RETORTS OF PORCELLAIN-BISCUIT, IN SIZES, PLAIN OR WITH  
 TUBULATION. .... 1s. 6d. to 10s. 6d.

RETORT AND CRUCIBLE STANDS, *fig. 7 and 8, pl. i.* .... 6d. to 1s.

TILLED RECEIVERS, OF DIFFERENT SIZES, PLAIN AND TU-  
 BULATED, *fig. 17, pl. xii.* ..... 3s. 6d. to 18s.

THESE are very useful vessels for removing at any time during distillation  
 the distilled liquid, without deranging the apparatus, when any change  
 of product is expected.

RETORT FUNNELS, *fig. 16, pl. xiv.* ..... 3s. 6d. to 7s.

BY means of these glass funnels fluids may be introduced into the body  
 of retorts, to prevent their necks from becoming soiled.

HYDROSTATIC FUNNELS, FOR CONVEYING LIQUIDS INTO AIR-  
 TIGHT VESSELS, *fig. 1, pl. ix, and fig. 20, pl. i.* .... 2s. 6d. to 3s. 6d.

THE use of this funnel is to pour fluids into retorts or other vessels  
 upon which any operation is going on, without admitting the external air,  
 and deranging any part of the apparatus.

IMPROVED APPARATUS FOR DECOMPOSING THE ALCALIES,  
*17, 11s. 6d.*

THIS contrivance is more simple and less costly than any other that  
 has been proposed, and answers very well the purposes which its title  
 expresses.

LABORATORY STILLS, OF TINNED COPPER, WITH REFRIGE-  
 RATORY—COMMON CONSTRUCTION, OF ALL DIMENSIONS,  
*fig. 6, pl. x.* ..... 2l. 2s. to 20l.

IMPROVED STILL, WITH REFRIGERATORY TO FIT PORTABLE  
 FURNACES, OR CHAFFING DISH, *fig. 8, pl. iv.* .... 2l. 2s. to 3l. 3s.

**STILLS ON THE SCOTCH PLAN,** *fig. 10, pl. x.... 2l. 12s. 6d. to 5l. 5s.*

**SMALL STILLS, COMPLEAT, TO ACT ON THE TABLE BY THE FLAME OF A LAMP..... 2l. 12s. 6d. to 5l. 10s.**

By means of this still all the processes of distillation for which the common still is intended may be performed, for experimental purposes, on the table, with much neatness and precision.

**GLASS ALEMBICS,** *fig. 21, pl. i, fig. 8, pl. xii, fig. 7, pl. xi.. 7s. 6d. to 2l. 2s.*

This distillatory apparatus, though less simple and more expensive than the retort, has many advantages in practice over the latter. The matter left after distillation may, in this vessel, be got at more conveniently, and may be much more easily cleared out when it adheres to the vessel. In experiments on sublimation, the alembic is particularly useful to receive the sublimed product, while the more volatile and elastic parts pass over into the receiver.

**ALEMBICS, OF PURE SILVER, WITH GLASS CAPITAL,**

*1l. 11s. 6d. to 5l. 5s.*

**EARTHENWARE ALEMBICS, WITH GLASS CAPITALS.. 7s. to 1l. 1s.**

These are less costly than those made entirely of glass, and less liable to accident.

**TUBES OF SAFETY, TO PREVENT THE BURSTING OF DISTILLATORY VESSELS, &c.** *fig. 17, pl. i..... 3s. 6d. to 10s. 6d.*

This ingenious contrivance, which is in fact a reversed syphon, effectually prevents the bursting of any distillatory apparatus, or other vessels to which it is applied, in case of a sudden extrication or condensation of a gaseous fluid, as must necessarily happen in many processes. And as this tube can be adapted to any part of the apparatus, it may be made to act precisely in the spot where the danger is expected to take place; it therefore supersedes other contrivances more complicated and expensive. It may likewise be employed to act as a cork to prevent the bad effects of having vessels either perfectly closed or perfectly open.

**CAPSULS, OR EVAPORATING BASONS OF FLINT GLASS, IN SIZES**

*1s. to 10s. 6d.*

MAPSULS OR BASONS, MADE OF GREEN GLASS ..... 1s. to 7s.

THESE basons being made of very hard glass, in the composition of which no oxid of lead enters, do not easily craek, and stand a low red heat in the sand-bath very well without bending or losing their shape.

VAPORATING BASONS OF BISCUIT WARE, WITH, OR WITHOUT LIPS, IN SETS OR SINGLE, *fig. 11, pl. i, per set.* 10s. 6d. to 11. 5s.

THE SAME, GLAZED ON THE INSIDE, WITH OR WITHOUT LIPS ..... Cd. to 6s. each.

These vessels are the most convenient for evaporation. Their flattened shape permits them to be heated more readily than those of glass, which cannot be made so shallow; and as the mass of the liquid intended to be evaporated has little depth and a proportional large surface, the evaporation takes place very rapidly. They may be placed over a clear coal fire, without much risk of craeking.

MATCH GLASSES, FOR EVAPORATING SMALL QUANTITIES OF FLUIDS ..... 6d. to 1s.

VAPORATING BASONS OF PURE GOLD ..... 2l. 2s. to 10l. 10s.

— OF PURE SILVER ..... 7s. 6d. to 4l. 4s.

— OF STANDARD SILVER ..... 5s. to 3l. 3s.

— OF PLATINA ..... 12s. to 5l. 5s.

CRUCIBLES (ENGLISH) ROUND, TRIANGULAR, &c. *fig. 9, 10, 11, pl. i* ..... 2d. to 1s.

ESSIAN CRUCIBLES, IN NESTS ..... 6d. and 1s. *per set.*

OF all the crucibles manufactured of earthenware, these are by far the best for supporting very intense heats without melting; they are, however, very liable to crack unless they are heated and suffered to cool very gradually.

BLACK LEAD CRUCIBLES, IN SIZES ..... 4d. to 7s.

THESE are not very liable to be cracked by sudden changes of temperature, and therefore but little precaution is requisite in using them. They

are very smooth within, so that the melted matters when poured out do not adhere to the inside. They are totally unfit for the fusion of alkaline and saline matters, and answer best for metals and metallic substances. They may be used more than once.

**WEIGHTS, IN DECIMALS, ACCURATELY ADJUSTED, FROM 1000 GRAINS DOWNWARDS TO  $\frac{1}{5}$  OF A GRAIN . . . . 18s. to 1*L*. 11*s*. 6*d*.**

With these weights the operator has always the same number of weights in the scales as there are figures in the number expressing the weights in grains. Thus 742, 5 ; grains will be weighed by the weights 700, 40, 2 and  $\frac{1}{3}$  ; and as the error of adjustment is the least possible when one weight is in the scale ; that is to say, as a single weight of five grains is twice as likely to be true as two weights, one of two and the other of three grains, because each of these last has its own probability of error in adjustment, the advantages of these weights above the common subdivision is obvious.

**SPECIFIC GRAVITY BOTTLES, WITH PERFORATED STOPPER, FOR FINDING THE DIFFERENCE BETWEEN MEASURES OF WEIGHT AND MEASURES OF CAPACITY . . . . 2*s*. 6*d*. to 10*s*. 6*d*.**

These bottles are convenient for ascertaining the comparative weight of two equal bulk's of liquids.

**THE SAME, WITH BALANCE WEIGHT . . . . . 15*s*. to 1*L*. 7*s*. 6*d*.**

**CUBIC INCH BOTTLES, FOR READILY ASCERTAINING THE SPECIFIC GRAVITY OF FLUIDS IN CUBIC INCH CAPACITIES . . . . . 4*s*. 6*d*.**

In adjusting the Bottles, the inch cube of distilled water is taken according to Sir G. S. Evelyn, Phil. Trans. v. 88, as corrected by Mr. Fletcher Phil. Journ. vol. iv, equal to 252, 500 grains Troy at 60° Fahr. ther and 29, 5 bar.

**ALCALIMETERS FOR APPRECIATING, IN A PROMPT AND EASY MANNER, THE COMMERCIAL VALUE OF POTASH, PEARL ASH, BAKILLA, AND OTHER ALCALIES . . . . 15*s*. to 1*L*. 11*s*. 6*d*.**

**HYDROSTATIC BALANCES, PACKED IN A BOX, fig. 12, pl. xli,**  
4*l*. 4*s*. to 5*l*. 5*s*.

HYDROSTATIC BALANCES, BEST CONSTRUCTION, WITH SLIDING STAND AND RACK, FOR LOWERING OR RAISING THE BEAM, &c. .... 5*l.* 15*s.* to 12*l.* 12*s.*

HYDROMETERS FOR ASCERTAINING THE RELATIVE STRENGTH OF ALCOHOL AND SPIRITUOUS LIQUORS, *fig.* 14 and 15, *pl.* xii ..... 3*l.* 13*s.* 6*d.* to 5*l.* 5*s.*

By means of this instrument the real strength of any kind of spirit, from alcohol to water, may be ascertained in an easy and expeditious manner.

HYDROMETER, OF BEAUME, FOR SALINE SOLUTIONS. 2*l.* 2*s.*

This hydrometer, though not a very correct instrument, is often employed by manufacturers for ascertaining the specific gravity of saline fluids. A table for reducing the degrees of the instrument into their corresponding expressions of real specific gravities, may be seen in Nicholson's Journal, 4to. edition, vol. i, p. 38.

BORING MACHINES FOR EXPLORING MINERAL STRATA,

10*l.* 10*s.* to 20*l.*

MODEL OF A MINE, PERPENDICULAR SECTION ..... 3*l.* 3*s.*

MINERS' COMPASSES, WITH OR WITHOUT LEVEL AND JOINTED SIGHT ..... 2*l.* 2*v.* to 3*l.* 3*s.*

MINERALOGICAL ELECTROMETERS ..... 15*s.* 6*d.* to 1*l.* 1*s.*

MAGNIFIERS, FOR EXAMINING MINERALS, *fig.* 5, *pl.* 15,  
5*s.* to 10*s.* 6*d.*

MAGNETIC NEEDLES, ON A STAND, FOR ASCERTAINING THE POLARITY OF MINERALS ..... 7*s.* to 10*s.* 6*d.*

MINERALOGICAL HAMMERS ..... 4*s.* 6*d.* to 7*s.* 6*d.*

IDITTO FOR THE POCKET ..... 3*s.*

MINERALOGICAL LABORATORIES, AND TRAVELLING CHESTS,  
5*l.* 5*s.* to 30*l.*

COLLECTIONS OF MINERALS, systematically arranged, 5*l.* 5*s.* to 100*l.*

COLLECTIONS OF ORES, EARTHS, AND STONES, FOR PRACTICAL ANALYSIS ..... 2*l.* 2*s.* to 10*l.* 10*s.*

DESIGNS, EXHIBITING THE CLASSIFICATION OF MOUNTAINS, THEIR GEOLOGICAL POSITION WITH REGARD TO EACH OTHER, THEIR CHARACTERS, &c. *single and in sets,* 3*l.* 3*s.* to 21*l.*

DESIGNS, ILLUSTRATING THE OCCURRENCE AND CHARACTERS OF MINERAL VEINS AND BEDS OF ORES, THEIR SUPPOSED RELATIVE AGE, DERANGEMENTS THEY HAVE SUFFERED, &c. .... 5*l.* 5*s.* to 10*l.* 10*s.*

POCKET MINERALOGICAL GONIOMETERS. .... 2*l.* 12*s.* 6*d.*

REFLECTIVE GONIOMETER—WOLLASTON'S, 3*l.* 13*s.* 6*d.* to 4*l.* 14*s.* 6*d.*

By means of this instrument the angles of crystallised bodies (even if the solid be very minute, and the radius in contact with its surface necessarily very short) may be measured with a degree of precision which has not hitherto been expected in goniometry. The accuracy of this instrument is such, that some capital errors in the former admeasurement of crystals have been corrected by it.

GALVANIC TROUGHS AND BATTERIES. .... 2*l.* 10*s.* to 5*l.* 5*s.*

GALVANIC PLATES, OF ALL DIMENSIONS. .... 1*s.* to 5*s.*

GALVANIC APPARATUS, FOR THE RAPID DECOMPOSITION OF WATER ..... 7*s.* to 10*s.* 6*d.*

APPARATUS, FOR OBTAINING THE ELEMENTS OF WATER IN A SEPARATE STATE BY GALVANIC ELECTRICITY, 12*s.* 6*d.* to 18*s.*

GALVANIC APPARATUS FOR OBTAINING OXIGEN AND HIDROGEN GASES FROM TWO QUANTITIES OF WATER NOT IMMEDIATELY IN CONTACT WITH EACH OTHER,

10*s.* to 18*s.*

LEPY'S APPARATUS FOR THE DECOMPOSITION OF FIXED  
ALCALIES BY GALVANISM..... 1*l.* 1*s.*

This apparatus affords an elegant and easy method of subjecting potash  
or soda to the action of galvanic electricity, and of preserving the pro-  
ducts arising therefrom.

GALVANIC PILES ..... 2*l.* 2*s.*

APPARATUS FOR EXHIBITING THE DECOMPOSITION OF WATER  
BY ELECTRICITY ..... 1*s.* to 1*l.*

TUNNELS OF GLASS, OF DIFFERENT AERAS, *fig.* 4, 6, *pl.* iii,  
1*s.* to 3*s.* 6*d.*

— OF PORCELLAIN BISCUIT ..... 1*s.* to 3*s.*

— OF BROWN STONE WARE ..... 1*s.* to 2*s.* 6*d.*

— OF WHITE STONE WARE ..... 1*s.* to 3*s.*

— WITH BENT NECKS, FOR CHARGING RETORTS,  
3*s.* 6*d.* to 7*s.*

— FOR SEPARATING DELIQUESENT SALTS, *fig.* 6, *pl.* viii  
7*s.* 6*d.*

APPARATUS FOR ASCERTAINING THE QUANTITY OF CARBO-  
NIC ACID DISCHARGED FROM ANY SUBSTANCE BY THE  
AFFUSION OF AN ACID ..... 5*s.* to 7*s.* 6*d.*

TUBE FOR COLLECTING PRECIPITATES ..... 2*s.* 6*d.*

The hollow ball of this tube is filled by the action of the mouth ap-  
plied to the upper orifice whilst the lower one is immersed in water.  
When the ball is filled, the water may again be forcibly driven out by the  
breath; and if directed against the inner sides of the filter, will wash down  
the bottom every minute particle of the precipitate adhering to it,  
and thus collect it together.

STANDS OF BRASS OR IRON, WITH SLIDING RINGS, AND WITH OR WITHOUT ADJUSTING SCREWS, FOR SUPPORTING RETORTS, FLASKS, BASONS, OR OTHER VESSELS, *fig. 6, 7, and 8, pl. xi.* ..... 10*s.* to 1*l.* 10*s.*

FILTERING STANDS, FOR SUPPORTING FUNNELS, JARS, BASONS, &c. DURING THE PROCESS OF FILTRATION, *fig. 29, pl. ix,* and *fig. 20, pl. iii.* ..... 12*s.* 6*d.* to 18*s.*

FILTERING FRAMES, FOR SUPPORTING STRAINERS AND OTHER KINDS OF FILTRES, *fig. 3, pl. v.* ..... 1*s.* 6*d.* to 5*s.*

WHERE no extraordinary nicety is required, the readiest way of filtering large quantities of fluids is, to throw them on a linen cloth covered with filtering paper, supported by frames of this kind.

FILTERING PAPER ..... 2*s.* 6*d.* to 5*s.* per quire.

FILTERING BAGS OF FLANNEL OR COTTON, *fig. 26, pl. xi,* 10*s.* 6*d.* to 1*l.* 5*s.*

TRANSPARENT SCREENS, TO DEFEND THE EYE AGAINST THE GLARE OF FURNACES WHEN IN FULL HEAT. .... 5*s.* to 10*s.* 6*d.*

TEST TUBES AND STAND FOR DITTO, *fig. 21, pl. iii.* 10*s.* 6*d.* to 18*s.*

THESE small tubes are very useful for observing the changes of colour, or other phenomena produced on bodies, by the action of re-agents or tests in chemical experiments in the small way. They also serve for dissolving minute portions of materials which require the assistance of a gentle heat.

WOODEN STAND, WITH MOVEABLE DISH, WHICH MAY BE SET TO ANY HEIGHT, FOR SUPPORTING RECEIVERS, &c. *fig. 22, pl. iii,* and *fig. 2, pl. ix.* ..... 7*s.* 6*d.* to 15*s.*

WOODEN BLOCKS, A SERIES OF WHICH, BY COMBINATION IN DIFFERENT WAYS, PRODUCE NOT LESS THAN THIRTY-ONE DIFFERENT HEIGHTS, FOR SUPPORTING ANY ARTICLE OF APPARATUS. .... 10*s.* to 18*s.*

SYPHONS OF METAL OR GLASS, *fig. 14, 15, pl. i.* ..... 2*s.* 6*d.* to 5*s.*

ITAL SYPHONS, WITH STOP-COCK.....7s to 12s.

I HOWARD'S DITTO, *fig. 20, pl. xi.*.....10s. 6d. to 17. 1s:

This syphon is useful in such cases where it would be disagreeable or dangerous to exhaust the legs of the instrument by the so called common mode of sucking out the air, as in drawing acids and other corrosive fluids.

EXHAUSTING SYRINGES .....10s. 6d. to 17. 5s.

RECIPIENTS, ITALIAN, FOR SEPARATING FLUIDS OF DIFFERENT SPECIFIC GRAVITIES, *fig. 13, pl. xiv.*.....5s. to 15s.

THIS vessel is more particularly useful in distillations employed for obtaining essential oils. It suffers the excess of water to escape, by its beak being placed in the lower part of its belly; and as this aperture is much lower than the neck or mouth of the vessel, the beak acts like a syphon when the vessel is nearly full to the brim; by this means the oil, floating on the surface of the water, is collected in the mouth of the vessel, whilst the water entering into the lower part of the spout flows off, and does not permit the oil to escape.

SEPARATORY FUNNEL, *fig. 21, pl. ix* .....10s. 6d. to 17. 10s.

THIS is another convenient vessel for separating liquids of different specific gravities, for instance, (oil and water) by allowing the heaviest only to drop out of the bottom of the vessel; the stop-cock at the bottom being closed and the vessel then filled with the mixed liquors. When they have stood at rest till the heaviest has entirely subsided into the narrow part below, the stop-cock at bottom is opened, and when the stopper at the top is loosened the heavier liquor flows out. This vessel is used particularly in separating essential oils from the water which is necessarily entangled with them when collected from the water distilled from the plants that yield them. Some of these are lighter than water, others heavier, and they are both separated with equal ease.

GLASS JARS WITH LIPS, CYLINDRICAL, FOR DECANTING FLUIDS, WASHING PRECIPITATES,&c. *fig. 7, pl. iii.* . 2s. 6d. to 7s.

PRECIPITATING GLASSES, *fig. 7 & 8, pl. viii.* ....., 1s. 6d. to 2s. 6d.

- BASONS OF EARTHENWARE, WITH SPOUTS .. 9d. to 2s. 6d.
- BASONS AND PANS OF COPPER, PLATED WITHIN WITH FINE SILVER..... 7s. to 2l. 12s. 6d.
- PANS OF IRON OR TINNED COPPER, *fig. 8, 12, pl. iii,* 12s. to 11s.
- PANS FOR BOILING INFAMMABLE FLUIDS, *fig. 16, pl. i,* 10s. 6d.
- WATER-BATH, OF AN IMPROVED FORM, FOR PREPARING EXTRACTS FOR THE PURPOSES OF PHARMACY, 1l. 5s. to 5l. 5s.
- WOODEN TUES, DOUBLE BOTTOMS, *fig. 2 pl. xii,* 18s. to 1l. 10s.
- FLASKS, VERY SMALL, *fig. 22, pl. i* ..... 9d. to 4s.
- ASSAY JARS, FLAT BOTTOMED..... 1s. to 5s. 6d.
- DIGESTORS AND EOLT HEADS, *fig. 3, pl. xiv.* 3s. 6d. to 10s. 6d.
- DIGESTING FLASKS, WITH SAFETY CONDENSORS, TO GUARD AGAINST THE BOILING OVER OF FLUIDS,
- GLASS MATRASSES ..... 4s. to 7s.
- SPOONS AND LADLES OF IRON, *fig. 11, pl. v.* 1s. 6d. to 5s.
- STEAM BATH FOR DRYING PRECIPITATES, OR EXPLOSIVE COMPOUNDS, *fig. 3, 4, and 7, pl. iv* ..... 7l. to 10s. 6d.
- This apparatus, which is adapted to fit the lamp-furnace, is particularly serviceable for drying such materials as cannot be exposed to a temperature exceeding that of boiling water without imminent danger, &c.
- TUBES OF PORCELLAIN BISCUIT, OF DIFFERENT LENGTHS AND BORES, GLAZED OR UNGLAZED ..... 1s. to 5s.
- These tubes are useful for the decomposition of oils and alcohol by a red heat, and for passing gases and other bodies over ignited substances.

## CRUCIBLES OF PURE SILVER ..... 8s. 6d. to 2l. 2s.

CRUCIBLES of perfectly pure silver are particularly useful, in analytical operations, for the fusion of bodies with alkalies, for which platinum vessel cannot be employed. The utmost degree of heat they can bear is that of moderate redness.

## CRUCIBLES OF PLATINA ..... 18s. to 5l. 5s.

On account of the absolute infusibility of platinum by the heat of chemical furnaces, and its perfect unalterability by most agents, these crucibles render the greatest service in the laboratory. They should always be put into a common crucible, to defend them from the direct action of the coals, the slack of which affixes itself to the sides and bottom with so much obstinacy, that it cannot be detached without risk of injury to the vessel.

## CRUCIBLES OF CAST IRON, IN SIZES ..... 1s. to 10s. 6d.

CRUCIBLES OF PORCELLAIN BISCUIT, IN NESTS OR SINGLE,  
1s. to 10s. 6d.

THESE crucibles should always be covered with a thin coating of Windsor loam, or common fire lute, before they are exposed to heat.

CRUCIBLE TONGS, OF VARIOUS KINDS, *fig. 2, 3, 4, 5, 6, 7, pl. v,*CRUCIBLE STANDS, *fig. 7, 8, pl. i* ..... 6d. to 1s.

By raising the crucible a few inches above the bars of the fire-grate in the furnace, the bottom part or cover is effectually exposed to the heat, which is not the case if this precaution be neglected; and as the strongest heat of furnaces is always within two or three inches of the grate, the crucible stand offers the most advantageous situation intended to be exposed to the action of the fire.

## CRUCIBLE COVERS, BLACK LEAD AND EARTHENWARE, 6d. to 1s.

CAR-SHAPED INGOTS, IN SIZES, *fig. 1, pl. v*, ..... 2s. to 10s. 6d.CASTING CONES, *fig. 3, pl. v* ..... 7s. to 10s. 6d.

MUFFLES AND CUPELS FOR ASSAYING, &c., <i>fig. 12</i> , <i>pl. i.</i>	5s. to 7s.
ENAMELLING PANS .....	2s. 6d.
ELECTRICAL MACHINES, VARIOUS SIZES, CYLENDERS OF PLATES, WITH CONDUCTORS, JAR AND APPARATUS,	
	7 <i>l.</i> 7 <i>s.</i> to 26 <i>l.</i> 5 <i>s.</i>
AMALGAM FOR DITTO, <i>per oz</i> .....	9 <i>d.</i>
ELECTRICAL BOTTLE, IN A POCKET CASE, WHICH BECOMES CHARGED BY THE RUBBING OF A VARNISHED RIBBAND .....	18 <i>s.</i> to 1 <i>l.</i> 1 <i>s.</i>
By means of this electrical apparatus, a small leyden jar may be instantly charged by a varnished silk ribband, exposed to the friction of a piece of cat's-skin rubber attached to the outside coating of the jar whilst the opposite electricity of the silk is carried off by the metallic knob of the jar communicating with the inside of the bottle.	
IMPROVED ELECTRICAL CONDENSORS.....	1 <i>l.</i> 10 <i>s.</i> to 2 <i>l.</i> 2 <i>s.</i>
BENNET'S ELECTROMETER .....	10 <i>s.</i> 6 <i>d.</i> to 15 <i>s.</i>
CONDUCTORS TO DEFEND EDIFICES, SHIPS, &c. AGAINST THE EFFECTS OF LIGHTNING.....	6 <i>l.</i> 6 <i>s.</i> to 10 <i>l.</i> 10 <i>s.</i>
PISTOLS AND CANNONS, FOR FIRING A MIXTURE OF OXIGEN AND HYDROGEN GAS BY ELECTRICITY ....	10 <i>s.</i> 6 <i>d.</i> to 1 <i>l.</i> 1 <i>s.</i>
BAROMETERS, USUAL CONSTRUCTION, <i>fig. 4</i> , <i>pl. viii.</i>	4 <i>l.</i> 14 <i>s.</i> 6 <i>d.</i>
BAROMETER, MORE ACCURATE, WITH ADJUSTING FLOAT AND RACK WORK NONIUS.....	5 <i>l.</i> 5 <i>s.</i> to 7 <i>l.</i> 17 <i>s.</i>
In this barometer the surface of the mercury in the cistern of the instrument may always be brought to a fixed level. <i>Fig. 5</i> , <i>pl. viii.</i> , exhibits the upper part of the instrument with its nonius.	
WHEEL BAROMETERS, <i>fig. 6</i> , <i>pl. vii</i> .....	3 <i>l.</i> 13 <i>s.</i>

MOUNTAIN BAROMETERS, ON AN IMPROVED PLAN, FOR ASCERTAINING ALTITUDES ..... 4*l.* 4*s.*

The great simplicity and portability renders this instrument superior to any mountain barometer yet constructed. It is not liable to be out of order; it may be used by a single observer or solitary traveller, and affords an easy method of ascertaining the elevations of the surface of the earth with the greatest facility, and to a degree of precision that may vie with trigonometrical mensuration.

BAROMETER TUBES, *per lb.* ..... 3*s.* 6*d.*

THIN GUAGES ..... 2*l.* 2*s.* to 3*l.* 3*s.*

CROMETERS, DE LUC'S, *fig. 8, pl. xiv.* ..... 4*l.* 4*s.*

MYTER'S NEW DITTO ..... 2*l.* 10*s.* 6*d.*

LESLIE'S DITTO, *fig. 6, pl. iv.* ..... 5*l.* 5*s.*

CHOTOMETERS, LESLIE'S, *fig. 5, pl. iv.* ..... 2*l.* 2*s.* to 2*l.* 12*s.* 6*d.*

PRISMS OF FINE CRYSTAL PASTE ..... 7*s.* to 10*s.* 6*d.*

THE SAME, MOUNTED ON A STAND ..... 3*l.* 1*s.*

PRISM, OF BRASS, REPRESENTING THE PRISMATIC SPECTRUM  
BY COLOURED SILKEN STRINGS ..... 2*l.* 10*s.* 6*d.*

PASS STOP-COCKS, IN SIZES ..... 5*s.* to 10*s.* 6*d.*

BUCKETS, MALE AND FEMALE, FOR CONNECTING STOP-COCKS, &c., *fig. 3, pl. viii.* ..... 2*s.* 6*d.* to 5*s.*

HINTS FOR UNITING LONG AND CROOKED METAL TUBES,  
WITHOUT THE NECESSITY OF TURNING THEM ROUND,  
OR DERANGING THE APPARATUS ..... 7*s.* to 10*s.* 6*d.*

HINTS FOR FIXING THERMOMETERS STEAM TIGHT INTO  
BOILERS AND OTHER VESSELS, *fig. 23 and 24, pl. ix.* 10*s.* 6*d.*

BUCKET MICROSCOPES ..... 1*l.* 16*s.* to 2*l.* 2*s.*

MAGNETS, IN BARS AND SETS OF BARS .....	2s. to 10s. 6d.
THE SAME, HORSE-SHOE SHAPED, STRONGEST FORM, .....	2s. to 17 1s
THE SAME, COMBINED TO ANY NUMBER OF SINGLE MAG- NETS.	
MAGNETICAL TOYS, FISHES, SWANS, &c. .....	5s. to 10s. 6d.
SAND-BATHS, OF CAST IRON, OF AN IMPROVED CONSTRUC- TION .....	2l. 10s. to 5l. 5s.
SPATULAS OF STEEL, IVORY, SILVER, OR PLATINA ..	1s. to 17. 1s.
ROPS OF GLASS AND ENAMEL, FOR STIRRING ACIDS AND CORROSIVE FLUIDS .....	6d. to 1s.
DIAMONDS FOR SCRATCHING GLASS.....	7s. to 10s. 6d
DITTO FOR CUTTING GLASS.....	1l. 1s.
CAPSULAS, OF WOOD, FOR GRANULATING METALS, <i>fig. 29</i> , <i>pl. ix</i> .....	2s. 6d.
RAPS AND FILES, <i>fig. 14, 15, 16, pl. xii</i> .....	2s. 6d. to 5s.
SAND-PANS, OF CAST IRON, FOR PORTABLE AND OTHER FUR- NACES, <i>fig. 17, pl. iii</i> .....	5s. to 10s. 6d.
LUTES OF ALL KINDS, <i>per pot</i> .....	1s. to 2s. 6d.
PLATINA, GOLD, SILVER, IRON, ZINC, LEAD, WIRE, &c.	
MORTARS AND PESTLES, OF GLASS, IN SIZES, <i>fig. 10, pl. iii</i> , .....	3s. 6d. to 10s.
— FLAT-BOTTOMED, FOR LEVEGATING WITH WATER BODIES PREVIOUSLY PULVERISED, <i>fig. 16, pl. iii</i> . . . .	5s. to 12s.

MORTARS OF PORCELLAIN BISCUIT, FROM  $\frac{1}{2}$  OF A PINT TO  
TWO QUARTS, *fig. 9, pl. iii.* ..... 2s. 6d. to 10s. 6d.

THESE mortars are the most useful for all the purposes of chemistry. They are exceedingly hard, and not acted on by any of the chemical agents in common use. They will bear a smart blow, and are perfectly smooth within, so that the pulverised substance does not stick to the sides.

LABORATORY MORTARS, COMMON SHAPE, OF CAST IRON,  
LARGEST SIZE, *fig. 4, pl. ii.* ..... 2l. 2s. to 5l. 5s.

IMPROVED DITTO, FOR THE TABLE, *fig. 6, pl. xii.* .. 15s. to 1l. 1s.

CAST IRON HAND MORTARS, PERFECTLY SMOOTH WITHIN,  
5s. to 14s.

THESE mortars are very convenient for breaking minerals and other substances that require hard blows, or to communicate them sufficiently for being farther pulverised in porcelain mortars.

STEEL MORTARS, FOR LEVEGATING GEMS, &c., *fig. 8, pl. xii.*,  
12s. to 1l. 10s.

STEEL MORTARS FOR CRUSHING MINERALS, *fig. 10, pl. xii.*,  
10s. 6d.

WOODEN MORTARS, *fig. 14, pl. iii.* ..... 10s. 6d.

MORTARS OF PORPHYRY, AGATE, JASPER, OR FLINT, *fig. 16,*  
*pl. iii.* ..... 1l. 1s. to 10l. 10s.

LEVIGATING STONES AND MULLERS, *fig. 18, pl. ix.* .... 7s. to 11s.

HAIR, LAWN, CAMBRIC, AND CYPRESS SIEVES, *fig. 17, 18, 19, pl. xi.*,  
3s. to 10s.

ACCURATE BALANCES, WITH CORRESPONDING WEIGHTS,  
IN SIZES, *fig. 13, pl. xi.* ..... 1es. to 1l. 15s.

BALANCES WITH GLASS PANS, PLAIN OR MOUNTED,  
1l. 1s. to 3l. 3s.

As there is frequent occasion in the medical pursuits to weigh substances

which quickly act on the metal pans of the balance, even if gilt, this contrivance will be found extremely serviceable in the laboratory ; glass pans are besides more easily kept clean than metal ones.

**ASSAY BALANCES** ..... 10*l.* 10*s.* to 15*l.* 15*s.*

**WIDE MOUTH GLASS JARS, WHICH CAN READILY BE RENDERED AIR-TIGHT, FOR PRESERVING SUBSTANCES FROM COMMUNICATING WITH THE AIR,** *fig. 5, pl. viii.* 7*s.* to 1*l.* 1*s.*

It is frequently necessary to close the openings of very wide-mouthed vessels intended to contain substances which would be injured by free exposure to the atmosphere, or by evaporation. Ground glass stoppers are seldom air-tight, and when they are, it happens that by the accumulation of particles of dust in the fitting, the stopper soon becomes immoveable. The method here adopted, is to have a glass jar, *a*, with a groove, *b*, half an inch deep round the outside of the top or mouth of the jar, and a glass lid, *c*, fitting loosely into the groove, which is rendered air-tight by hog's lard, a substance never quite fluid at the highest temperature of this climate, and always soft enough in the cold season to admit of removing the lid or top of the jar.

**BARUEL'S APPARATUS FOR MAKING GAZEOUS OXID OF CARBON,** *fig. 9, pl. ii.* ..... 12*l.* 12*s.* to 15*l.* 15*s.*

THE object proposed in this arrangement is to oblige the gas evolved from carbonate of lime to traverse charcoal contained in three gun-barrels, and thus to saturate itself with all the carbon it can dissolve. It may likewise be used for procuring sulphuretted hydrogen, carburetted hydrogen, phosphoretted hydrogen, and for saturating gases with any substance whatever, when a high temperature is requisite for that purpose. The apparatus, however, is too complex, too expensive, and too easily put out of order, to deserve general adoption. *Fig. 10* shows a horizontal section of the furnace ; *aaa* are the gun-barrels ; in *fig. 9 b* is a pneumatic cistern, and *c* the bottle from which gas proceeds into the barrels.

**IMPROVED DISTILLATORY REFRIGERATORY,** *fig. 9, pl. viii,*  
1*l.* 10*s.* 6*d.* to 3*l.* 3*s.*

This refrigeratory or condenser is of a form that allows the greatest cooling surface that can conveniently be given in the round tub, or water-reservoir, in which it is placed ; it consists of two concentric cylinders, or rather inverted truncated cones, one within the other, but leaving a

small interval, or void space, which is closed at the upper as well as lower end; in this interval, or void space, the condensation of the vapour is effected by the cold water which surrounds the outer and fills the inner cone; by this form, a very large and double cooling surface is obtained, in a small and convenient space.

LARGE COPPER BOILERS, *fig. 6, pl. vi* ..... 2*l. 2s. to 5*l. 5s.**

CAVOISIER'S APPARATUS FOR SHOWING THE COMPOSITION OF WATER, *fig. 6, pl. xv* ..... 12*l. 12s.*

APPARATUS FOR SHEWING THE SPONTANEOUS ACCENSION OF OXI-MURIATIC ACID GAS AND AMMONIA BY MERE MIXTURE. .... 10*s. 6d. to 1*l. 1s.**

APPARATUS FOR MAKING PHOSPHOROUS ACID, *fig. 5, pl. ii,*  
1*l. 15s.*

APPARATUS FOR PREPARING PHOSPHORIC ACID BY THE RAPID COMBUSTION OF PHOSPHORUS, *fig. 3, pl. ii.* ... 2*l. 2s.*

APPARATUS FOR PREPARING OXI-MURIATIC ACID, AMMONIA, &c., *fig. 6, pl. xi* ..... 2*l. 12s. to 3*l. 3s.**

GUN-BARREL APPARATUS, WITH PORTABLE FURNACE, AND WITH OR WITHOUT WOULF'S BOTTLE, HYDROSTATIC FUNNEL, TUBE OF SAFETY, PNEUMATIC JARS, &c. *fig. 18, pl. i, and fig. 27, pl. xi* ..... 3*l. 13s.*

COMPOUND DISTILLATORY APPARATUS, *fig. 5, pl. x* ..... 3*l. 3s.*

MACHINES FOR FILTERING WATER BY ASCENT, *fig. 3, pl. xii,*  
4*l. 14s.*

PORTABLE BRICK SAND-BATH FURNACES, SQUARE, *fig. 23, pl. iii,*  
3*l. 13s.*

PORTABLE BLACK LEAD DOOM FURNACES, *fig. 24, pl. iii,* 3*l. 13s.*

*And every other apparatus or contrivance which the progress of Science shall bring forth in the field of Chemical Philosophy, Mineralogy, and the Arts connected with these branches of knowledge.*

## CHEMICAL CHESTS.

*The chemical apparatus and bottles contained in the following Chests are arranged in such a manner, that they may be seen at one view when the chest and drawers are open; they are besides so packed that they can readily be taken out, and when replaced fit in such a way, that the whole, when the chest is locked, may be turned upside down without risk of receiving injury.*

*Chests, containing a select Collection of Chemical Re-agents or Tests .....* 3*l. 3*s.* to 1*l. 1*s.***

*Ditto, more compleat; to which are added the Chemical Apparatus usually employed in the processes of analysis by means of Tests .....* 7*l. 7*s.* to 8*l. 18*s.* 6*d.***

CHEMICAL re-agents or tests are called those bodies which are employed in the practice of chemistry to ascertain the composition of other substances, upon which they quickly act and produce, with them, changes sufficiently striking to the senses, from which the nature or quality of the unknown substance may readily be inferred. Hence the best chemists, at all times, have considered the study of tests of infinite service to the successful practice of the science; because the phenomena which they produce form an assemblage of facts which have singularly added to the progress of chemical philosophy. Besides, the knowledge of the action of these bodies, and their practical application, demands no skill nor effort of mind. They form the compass by which the chemist steers; and it may be affirmed, that he who is intimately acquainted with the general philosophy of chemical tests, knows all the science has to offer. To this may be added, that many useful discoveries may be made by the mere help of a few chemical re-agents of different kinds, because *a general knowledge of the composition of bodies is sufficient to direct the application of the substances of nature to useful purposes in the affairs of life.*

*Pocket Mineralogical Blowpipe Apparatus .....* 3*l. to 4*l.**

No department of physical science has of late years been more cultivated than mineralogy. It embraces a wide circle of votaries among the curious

the wealthy classes of the community, and it is intimately connected with the passion and laudable desire of exploring the productions of nature which characterises the present state of society. In the study of this branch of physical enquiry, the pocket blowpipe apparatus, which joins the convenience of a small size, and the facility of being easily transportable, is of singular advantage. It enables the mineralogist to expose instantaneously, to the action of a most violent heat, the substances he may meet with in his excursions or elsewhere, with a view to ascertain their mineral nature or qualities with regard to fire; for some minerals, on exposure to the blowpipe dart, are volatilised; in others the colour is changed; and while some are nearly fused at different temperatures, others again burn with a flame of a peculiar colour, &c.

#### *Mineralogical Travelling Chests . . . . . 10*l.* 10*s.* to 13*l.* 13*s.**

Though the blowpipe assay is usually sufficient to furnish general notions concerning the substances of the mineral kingdom, those who study mineralogy as a science, are not content with this kind of analysis, because it does not afford the information they require. By always operating on small fragments, the results obtained are too minute to enable the operator to determine quantities with accuracy; besides, part of the metal escapes in vapour; part remains in the flux; the metal itself more or less impure, and its mineralising substance is dissipated or consumed in the flux. Hence the action of certain acids and tests are necessary to assist the imperfection of the blowpipe assay. By the application of these bodies the general nature of a mineral substance may be easily and quickly ascertained. To effect this, the mineralogical travelling chest is fitted up. It contains every thing essential for that purpose, and nothing superfluous. It is adapted, however, for the examination of those minerals only, that are usually met with in this country; such as ores of copper, iron, tin, lead, antimony, &c.

#### *Accum's Mineralogical Laboratories . . . . . 15*l.* 15*s.* to 18*l.* 18*s.**

#### *The same, more compleat . . . . . 26*l.* to 36*l.**

This portable laboratory contains a compleat collection of the most approved apparatus and instruments necessary for carrying on in general the analysis of mineral substances of all kinds. *It forms a companion to Accum's Manual of Analytical Mineralogy, intended to facilitate the practical analysis of metallic ores; earths, stones, and other subjects of the mineral*

*kingdom; in 2 vols.* A drawing and full description of this mineralogical laboratory may be seen in the Philosophical Magazine, No. clvii, 1811. The approbation which this portable case of chemical instruments, &c. has met with, and the public sanction it has received from different quarters to which we might refer, gives reason to believe that it has proved useful amongst the cultivators of mineralogical science.

*Portable Chemical Laboratories, for carrying on a general Course of Chemical Experiments . . . . . 30*l.* to 80*l.**

If the progress in the study of any experimental science depends on the facility with which those expositions that form its basis can be displayed, the study of chemical philosophy must become greatly facilitated by acquiring, at the commencement of it, a general knowledge of all those experimental facts and multifarious operations that are best calculated to unfold the leading doctrines of the science. This object may now be accomplished with such facility, as formerly would have been thought impossible. Since chemistry has changed its appearance; since its instruments of experiments have been perfected, and acquired new form, new paths for exploring the productions of nature have also been opened, the art of experimenting has been simplified, and become more familiar and easy. Experience has thus shown, that however varied the objects of research may be, and however numerous and different the products to be obtained may appear, the operator is now enabled to perform, at a trifling expence, his processes in the closet with more precision and perspicuity than could formerly be done in the regular laboratory fitted up with costly instruments. Besides, all those operations which, in the large way, require several days labour, can, in the small way, be finished in a few hours. The numerous processes of digestions, the sublimation of salts, the solution of earthy, metallic, and other bodies, the concentration of saline liquids, the desulphuration of metallic ores, the processes of distillation by the naked fire or the sand-bath, and even the production of gases, and fusion of earthy fossils with alkalies, may be accomplished, at a trifling expence, by the help of the portable laboratory, with much neatness and precision.

*Chests of Chemical Amusement . . . . . 10*l.* 10*s.* to 18*l.* 18*s.**

The object of this chest is to blend chemical science with rational amusement. The pleasing appearances which chemistry affords, whilst they amuse, by presenting to the observer striking phenomena and unexpected

results, are well calculated to diffuse mirth and surprise through a friendly circle. But that this chest might be rendered of greater value than the mere amusement of a leisure hour, the rationale of each experiment has been given in the publication which accompanies the chest—(*Chemical Amusement: comprising Minute Instructions for performing a Series of striking and instructive Chemical Experiments: 1811*). And with regard to the striking experiments which chemistry affords, such only have been selected on the present occasion, as may be performed with ease and safety by those who are moderately tinctured with chemical knowledge. It is presumed they will be found well calculated to rivet attention, and display that fascinating character for which the science of chemistry has higher claims than any other branch of knowledge. Indeed, so singular and curious are the phenomena produced by this science, that to be welcomed and cultivated, it needs only to be known.

Agricultural Chests ..... 7*l.* 7*s.* to 12*l.* 12*s.*

THE methods of ameliorating land are intimately connected with chemistry. This chest is intended to enable the farmer to perform the chemical examination of soils, manures, marls, lime-stones, &c. with a view to ascertain their agricultural value. It contains the instruments and chemical preparations necessary for that purpose.

Cabinets of Chemical Specimens ..... 21*l.* to 31*l.* 10*g.*

THESE CHESTS CONTAIN AN ASSORTMENT OF THE MOST IMPORTANT CHEMICAL PREPARATIONS WHICH ARE OF GENERAL USE IN CHEMISTRY, SUCH AS THE PUR-ARLTHS, ALKALIES, METALS, OXIDS, SALTS, &c.

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<i>Auriferous Ether</i> , for gilding highly polished steel by mere immersion, <i>per bottle</i> .....	2s. 6d.
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<i>Gold Powder</i> , for gilding silver, by friction, <i>per paper</i> .....	5s.
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<i>Spoons</i> , of the same metallic alloy, <i>each</i> .....	9d.
<i>Sympathetic Ink</i> , which when written with on paper, is, and remains invisible whilst kept in the dark, and becomes visible when the writing is exposed to the light of day or the direct rays of the sun, <i>per bottle</i> , ..	1s.
<i>Blue Sympathetic Ink</i> . Writings made with it are invisible when dry, but speedily assume, when held before the fire, a greenish blue colour, which again departs as the paper becomes cold, <i>per bottle</i> , ..	1s. 6d.
<i>Yellow Sympathetic Ink</i> . Characters written with it when dry are invisible, and may be made to appear or to depart successively, by alternately warming the paper or suffering it to cool, <i>per bottle</i> .....	1s.
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<i>Two Transparent Fluids</i> , which by mixture instantly become converted into an opaque and almost solid mass, <i>per bottle</i> .....	1s. 6d.

<i>Mixture of Nitrate of Strontia and Alcohol</i> , which when set on fire burns with a carmine red flame, per bottle .....	2s.
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<i>Nitrate of Copper</i> , for setting tin-foil on fire, per bottle.....	1s.
<i>Solution of Silver</i> , for illustrating the astonishing divisibility of matter, per bottle .....	1s. 6d.
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<i>Phosphorized Oil</i> , renders bodies luminous in the dark, and gives sufficient light to admit of the hour being seen on the dial of a pocket watch during night, per bottle.....	1s. 6d.
<i>Grid of Phosphorus</i> , when applied to a sulphur match sets it on fire by friction, per bottle .....	3s.
<i>Phosphoric Fire Bottles</i> , ditto .....	2s. 6d.
<i>Illuminating Powder</i> , per bottle .....	1s.
<i>Emeral Chameleon</i> , which tinges cold water green, purple, and red— and hot water pink and crimson, per bottle .....	1s.
<i>Silver Test</i> , for instantly detecting counterfeit silver coin, or silver of British standard, per bottle .....	1s.
<i>Gold Test</i> , for detecting counterfeit gold coin, or gold of British standard, per bottle .....	1s. 6d.

<i>Liquid Bronze</i> , for instantly bronzing copper, brass, &c. per bottle....	1s.
<i>Wine Test</i> , for detecting the deleterious adulteration of wine, cyder, &c. per bottle .....	2s. 6d.
<i>Vinegar Test</i> , for detecting the genuineness of vinegar.....	1s.
<i>Preparations</i> for making instantly artificial seltzer or soda water.....	5s.
<i>Bleaching Liquid</i> , for discharging stains of red wine, tea, fruit, mildew, &c. out of linen, muslin, cambric, lace, and other articles, and for restoring linen or cotton goods when discoloured by age, washing, &c. to its original whiteness, per bottle .....	2s. 6d.
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<i>Fluor Spar</i> , for etching on glass, per lb. ....	1s. 6d.
<i>Solution</i> , for shewing the precipitation of silver in a brilliant metallic and arborescent form .....	1s.
<i>Amalgam</i> , for silvering the internal surface of glass globes, per oz....	1s.
<i>Lycopodium</i> , for producing artificial lightning, per box .....	1s.
<i>Pyrophorus</i> , which burns spontaneously on exposure to air, and when poured into a jar of oxygen gas forms a brilliant fiery shower..	2s. 6d.
<i>Cantons Phosphorus</i> .....	2s.
<i>Bologna Fuchs</i> , per dozen.....	18s.
<i>Rupert's Drops</i> , per dozen .....	8d.

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IN PHILOSOPHICAL CHEMISTRY,  
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*The articles enumerated in this List are all in a state of absolute purity, except such as are distinguished by the word commerce, by which is meant the state in which they are usually met with in commerce. The letter D denotes that the substance is in a dry, or crystallized state; and S implies solution.*

ACETATE Alumine, S.....per oz. 6d	Acid Phosphoric, S ..... 3s 6d
Barytes, D.....2s	Ditto of commerce, S ..... 1s
Ditto, S.....6d	Ditto vitrious ..... 2s
Copper, D.....1s	Phosphorous, S..... 3s 6d
Cobalt, S.....2s. 6d	Prussic ..... 1s 6d
Iron, S.....6d	Pyroligneous ..... 6d
Lead, D.....9d	Sabaeic..... 6s
Ditto, S.....6d	Succinic, D ..... 8s 6d
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Potash, D.....1s	Sulphuric ..... 6d
Silver, D.....5s	Ditto of commerce ..... 9d
Ditto, S.....1s	Sulphurous..... 1s 6d
Soda, D.....1s	Tartaric, D ..... 2s 6d
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Acid Acetic ..... 1s 6d	Tungsten Ores—Specimens, 2s to 10s
Ditto of commercee..... 1s	Aleohol ..... Spec. Gr. 825.. 9d
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Boraci, D.....2s	Ammoninret Copper, D ..... 1s
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Muriatic ..... 6d	Aurum Musivum ..... 3s Cd
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Mucous, D ..... 3s 6d	Barytie Stones—Specimens, 1s to 5s
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Ditto of commercee ..... 3d	Barilla ..... 4s
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Ditto of commercee, D...2s 6d	Ditto of commercee ..... 6d
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Carbonate Ammonia, D .....	1s 6d	Permanent .....	5s
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Barytes .....	1s 6d	Wire .....	
Ditto native .....	lb. 2s 6d	Turnings .....	
Copper .....	per oz. 1s 6d	Iron Ores—Specimens .....	1s to 7s
Iron .....	6d	Lead .....	6d
Lead .....	6d	Foil .....	8d
Magnesia .....	3s 6d	Lead Ores—Specimens .....	1s to 7s
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Ditto, dried .....	1s	Lime Stones—Specimens of such	
Soda, D .....	9d	as are injurious to agriculture, 3s	
Ditto, dried .....	1s 3d	Litmus, D .....	9d
Strontia .....	1s 6d	Tincture .....	7d
Chamelion Mineral .....	2s	Paper .....	per sheet, 6d
Copper .....	1s	Lycopodium .....	per oz. 1s 6d
Ditto of commerce .....	3d	Magnesia .....	3s
Filings, commerce .....	6d	Magnesian Stones—Specim. 3s to 7s	
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Copper Ores—Specimens .....	1s to 5s	Mercurial Ores—Specimens .....	7s
Cobalt .....	10s	Muriate Alumine, S .....	6d
Ditto of commerce .....	5s	Ammonia, D .....	9d
Cobalt Ores—Specimens .....	4s to 10s	Ditto of commerce .....	6d
Ether Acetic .....	5s	Barytes, D .....	1s 6d
Muriatic .....	5s	Ditto, S .....	6d
Nitric .....	3s 6d	Bismuth, S .....	6d
Sulphuric .....	2s	Copper, S .....	1s
Ditto of commerce .....	1s 6d	Cobalt .....	2s 6d
Fluare Soda, S .....	1s 6d	Gold, S .....	2l 8s
Ammonia, S .....	1s 6d	Ditto, S .....	8s
Fluor Spar .....	per lb. 1s	Iron, S .....	6d
Fuse, Crude .....	per oz. 6d	Lime, D .....	9d
Black .....	9d	Ditto, S .....	6d
White .....	10d	Ditto oxygenized, D .....	6d
Guitone .....	6d	Mercury, D .....	8d
Fulminating Gold .....	10l 10s	Ditto, S .....	6d
Mercury .....	12s	Ditto oxygenized .....	1s
Powder .....	6s	Platina, S .....	2s 6d
Silver .....	per dr. 8s	Do. and Ammonia, D .....	5s 6d
Fuming Liquor of Boyle, per oz. 3s 6d		Strontia, D .....	2s
Fusible Alloy .....	9d	Tin, S .....	6d
Gold Leaf .....	2s 6d	Mineral Chamelion .....	2s
Wire .....		Minerals, Collections, containing	
Gold Ores—Specimens, 7s to 11 10s		Specimens of the most important	
Hydrosulphuret Ammonia, per oz. 3s		Ores, Earths, Stones, &c. 5l 5s to 50l	
Lime .....	6d	Naphtha .....	per oz. 9d
Potash .....	6d	rectified .....	1s 6d
Hyperoxy-muriate Potash, D .....	4s	Nickel .....	8s
Linne, D .....	6d	Ditto of commerce .....	3s
Hydrate of Barytes .....	6s	Nickel Ores—Specimens .....	3s to 15s
Ditto of Strontia .....	9s 6d	Nitrate Ammonia, D .....	9d
Iridium, Ore of .....	15s	Barytes, D .....	1s 6d
Ink, Blue Sympathetic .....	2s. 6d	Ditto, S .....	6d

Nitrate Copper, D .....	1s 6d	Potassium .....	-
Lead, D .....	1s	Prussiate Ammonia .....	1s
Ditto, S .....	6d	Prussiate Lime, S .....	1s
Mercury, D.....	1s 6d	Potash, D .....	2s
Ditto, S.....	6d	Ditto, S .....	1s
Potash, D.....	6d	Mercury, D .....	2s
Silver, D .....	8s	Ditto, S .....	1s
Silver, S .....	2s 6d	Purple Powder Cassius.....	4l 12s
Ditto fused.....	8s	Pyroligneous Acid .....	6d
Nitrate Strontia, D .....	3s	Rhodium .....	
(Oil Wine .....	2s 6d	Salt of Sorrel, D.....	1s 6d
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Ditto, S .....	1s 6d	Silicited Potash, D .....	2s 6d
Potash Acidulous, D 1s 6d		Ditto, S .....	9d
Oxid of Arsenic .....	6d	Silver Leaf .....	per book, 2s
Bismuth.....	1s 6d	Wire .....	
Cobalt.....	8s	Silver Ores—Specimens .....	5s. &c.
Copper, brown .....	2s	Soda, D .....	per oz. 3s 6d
Do. red .....	1s	Ditto of commerce, D.....	1s 9d
Lead, yellow .....	6d	Sodium .....	
Do. red .....	3d	Soils, collection of Tests and Appa-	
Do. vitrious .....	3d	ratus for their analysis ..	4l 4s
Mercury, red .....	7s	Strontia, D .....	8s
Manganese, nat. best, lb. 1s		Ditto Hydrate.....	9s 6d
Ditto of commerce .....	6d	Strontia Water .....	6d
Nickel.....	per oz. 9s	Strontia Stones—Specimens, 3s. &c.	
Tin, white.....	1s 6d	Subcarbonate Ammonia, D .....	9d
Tungsten .....	12s	commerce, D.....	6d
Oxi-muriate Lime, D.....	6d	Magnesia .....	6d
Mercury, D .....	1s	Potash, D .....	6d
Ditto, S.....	8d	Ditto of commerce	3d
Potash, D .....	4s	Soda .....	9d
Tin ..	3s	Ditto of commerce	3d
Oxi-phosphate iron .....	1s 6d	Succinate of Ammonia, S....	2s 6d
Oxi-sulphate of iron .....	6d	Soda, S.....	8s
Petroleum .....	9d	Ditto, S .....	1s 6d
Phosphate Iron, D.....	1s	Sulphate Barytes, native, lb. 1s 6d	
Soda, D .....	6d	Iron, D.....	6d
Do. & Ammonia, D 2s 6d		Magnesia, D .....	6d
Phosphorus .....	2s	Ditto of commerce.....	2d
Ditto of commerce .....	7s	Ditto, S .....	2d
Phosphorized Oil .....	1s 6d	Mercury, D.....	1s
Alcohol.....	1s	Potash, D .....	6d
Ether .....	2s 6d	Silver, D.....	6s
Fire Bottles....	2s 6d	Ditto, S.....	1s 6d
Latina of commerce .....	5s	Soda, D .....	2d
pure .....	20s	Strontia, native, lb. 2s 6d	
Wire.....	21s	Zinc, D. .... per oz. 6d	
Lates of Copper, polished ..	1s 6d	Sulphur .....	3d
Zinc, ditto .....	1s 6d	Sulpkur—native specimens .....	4s
Iron, ditto .....	1s	Sulphuret Antimony .....	6d
Potash, D .....	2s 6d	Arsenie .....	6d
Ditto of commerce, D.....	6d	Ditto, red .....	6d

Sulphuret of Arsenic, yellow.....	6d	Tin Ores—Specimens.....	3s. &c.
Iron.....	8d	Turpith Mineral .....	1s 6d
Lead, native.....	3d	Tineture Red Cabbage .....	7d
Lime .....	1s 6d	Litmus .....	7d
Mercury .....	1s	Brazil Wood .....	7d
Potash.....	9d	Turmerie .....	7d
Super-acetate Lead, D.....	9d	Galls .....	8d
Ditto, S .....	6d	Turmeric Paper .....	7d
Oxalate Potash, D ..	1s 6d	Verditer, blue .....	1s
Ditto, S .....	6d	green .....	1s
Sulphate Mercury, D, 1s 6d		Vermillion .....	1s
Sympathetic Ink, blue .....	2s 6d	Vinegar, Distilled .....	6d
green .....	2s	Wine Test .....	6d
yellow .....	1s	White Flux .....	10d
Tan, S.....	1s	Zaffre .....	1s
Tartrate Potash and Soda, D ..	6d	Zinc .....	6d
Iron .....	6d	Ditto of commerce.....	2d
Test Papers.....	per sheet, 6d	Malleable.....	8d
Tin .....	6d	Filings .....	6d
Ditto of commerce.....	2d	Wire .....	6d
Foil .....	6d	Granulated .....	6d
Tin Filings.....	6d	Zinc Ores—Specimens.....	2s. &c.

## DIRECTIONS

FOR

FITTING UP A LABORATORY FOR PHILOSOPHICAL CHEMISTRY,

AND

LIST,

CONTAINING A SELECT COLLECTION

OF THE MOST

USEFUL CHEMICAL PREPARATIONS AND INSTRUMENTS,

FOR CARRYING ON

A GENERAL COURSE

or

CHEMICAL EXPERIMENTS.

IT was once thought that a regular laboratory, or place built on purpose, and fitted up with forges and brick furnaces, was absolutely necessary for the practice and study of the science of chemistry. This is by no means the case. In proportion as chemical philosophy has become extended, the art of operating has been simplified, new methods of research have been discovered, and new instruments have been added to those which we already possessed. It is no longer deemed necessary to make experiments upon large quantities, for the same properties which characterise minute portions of matter are also found in a whole mountain of the same substance. Indeed, most experiments of *study* may be more easily performed on a small, than on a large scale; and a great deal of expense is saved. Besides, we may in many instances apply powerful agents, and the most

expensive materials, which cannot be adapted to large quantities of substances. Thus, were it not for the assistance of the electrical machine, the galvanic battery, and the blowpipe, upon minute portions of substances, a vast number of valuable facts which have changed the face of chemistry within our time, would probably have remained undiscovered. It was by operating upon *grains of matter* that the nature of the diamond was established; that no less than four new metals have been detected in the ore of platina; that the composition of the stones which fall from the clouds has been determined; that the metallic basis of the alkalies has been brought to light; and that the identity of the electric agency, whether excited by the common machine, or by the pile of volta, has been demonstrated. There is, besides, a degree of neatness gained by operating in the small way in the closet, which is often incompatible with processes conducted on a large scale, amongst the furnaces of the regular laboratory.

For carrying on the modern practice of philosophical chemistry, a common apartment either on, or above, the ground floor, well lighted and ventilated, and having a common fire place, may be made to answer exceedingly well. A laboratory on the ground floor is thought by many most convenient, for the sake of water, pounding, and washing. It certainly has these advantages, but it is also subject to great inconveniences. In such a place most salts and saline substances become moist in time, the gummed paper labels of bottles fall off, the bellows and many other articles rot and become mildewed, the scale-beams and metals rust, and every thing almost spoils; a room above the ground-floor is therefore preferable. The only advantage that can be derived from a ground-floor is, the convenience of being easily supplied with water, but this is not at all counterbalanced by the inconvenience of dampness. Let there be placed in the middle of the room, a heavy table or kitchen dresser, with drawers below. This table may serve as the common place for operating with the furnace, for making preparations for processes, for performing solutions, filtrations, precipitations, and in fact for all processes which do not require the intense heat of the furnaces. In the drawers may be kept the blow pipes, and their appendages; the thermometers; glass, silver, and platina evaporating basons; alembics; porcelain, earthenware, and other tubes; platina, silver, and glass rods; spatulas; eudiometers; gas bottles; hidrostatic funnels; weights; cubic inch measures; small crucibles; stop-cock; filtering paper; vials; corks; bladders; leather; packthread, &c. Let the sides of the room be fitted up with shelves, and one or more nests of drawers, such as are seen in apothecaries' shops; a cupboard with shelves will also be found extremely useful. The shelves arranged round the room may serve to support glass, earthenware, and other vessels; the nests of drawers and cupboard are intended to preserve the products of the operations and other dry articles. In one corner of the room, if it can conveniently be done, a common stone sink should be put up, with a reservoir containing an abundance of water. As the vessels are always cleaned in the sink, cattle brushes, wires, sticks of whalebone, sponges, towels, and a rack for draining vials, ought to be near it. In another corner may be placed a heavy solid block of wood, to serve as a support for mortars when pounding hard substances, and in which also an iron anvil may be stuck occasionally. Near this place should be hung upon hooks, sieves of different fineness, rasps, files, hammers, shears, pincers, scissars, &c. The fire-place of the room should be made as wide as possible, to receive the furnaces which make much dust and flame. Indeed, if it can be

done, the opening of the chimney should extend from one wall to another; and it should be so high, that a person may easily stand under it. The rest of the space of the chimney ought to be fitted up with one or more stands of different heights, on which small portable furnaces and other apparatus may occasionally be placed. Under the chimney, at a convenient height, should be a row of iron hooks driven into the back and sides of the wall, upon which are to be hung hand-bellowes, shovels, crucible and fire tongs, pokers, ladles, ingots, and other utensils for managing the vessels to be used with the furnaces, and for disposing the fire. A book-case with glazed doors, to hold the finer apparatus, such as balances, &c. and a few choice books, will likewise be highly convenient. If more than one room can be adapted for the purposes of a laboratory, it will be more advantageous to have one apartment on the ground floor and another in the upper story of the house. The first should be appropriated for the furnaces, and the performance of those processes which occasion smoke or corrosive vapours; for sifting, pounding, evaporating and other processes which make dust or fumes; and in the upper room the finer processes, and those which require the mere heat of a lamp, should be performed. This arrangement being made, the following articles should be procured:—

*The word PURE, in this List, (like in page 51,) implies that the article ought to be in a state of absolute purity; and the word COMMON, means that the same substance should also be kept in the laboratory in the state it is usually met with in commerce; because the ordinary degree of purity of several substances is often sufficient for common chemical purposes; and thus a considerable saving of expense will accrue to the operator. The prices at which the articles are sold, having been mentioned already in the preceding pages, it is not necessary to repeat them. Chemical Societies, and Gentlemen, who are at a distance from town, may have explanatory lists made out similar to this, to meet their ideas as fully as possible, according to the object in view, and expense they are willing to incur. Further instructions and designs for fitting up laboratories will be given, if required.*

## I. CHEMICAL PREPARATIONS.

### ACIDS.

Sulphuric Acid, pure and common; Nitric Acid, pure and common; Nitrous Acid; Muriatic Acid, pure and common; Oxi-muriatic Acid, to be kept in the dark, or in opaque bottles, and Mixtures of these Acids and Water in two or three different known proportions; Tartaric Acid.

### EARTHS.

Silex; Alumine; Magnesia; Barytes; Strontia; Lime.

### ALCALIES.

Potash, pure and common; Soda, pure and common; Ammonia, pure and common; and solutions of these Alkalies in water in different known proportions.

### METALS.

Iron Filings and Wire; Copper, pure and common, and Copper Clippings; Granulated Zinc; Lead Foil; Silver Leaf and Wire; Gold Leaf and Wire; Tin Foil and Filings; Platina Foil and Wire; Quicksilver; Bismuth.

## TESTS.

Red Cabbage Tinctor; Litmus Tinctor; Turmeric Tinctor; Brazil Wood Tinctor; Tinctor of Galls; Papers stained with these Tinctors; Alcohol, pure and common; Solution of Oxid Arsenic; Solution of Acetate Barytes; Solution of Sulphate Silver; Barytic Water; Hydro-sulphuret Lime; Lune Water; Solution of Acetate Lead; Solution of Muriate Bismuth; Solution of Muriate Barytes; Solution of Muriate Gold; Solution of Muriate Tin; Solution of Muriate Lime; Solution of Muriate Platina; Solution of Nitrate Lead; Solution of Nitrate Barytes; Solution of Nitrate Silver; Solution of Oxalic Acid; Solution of Oxalate Ammonia; Solution of Prussiate Potash; Solution of Prussiate Lime; Solution of Prussiate Mercury; Solution of Soap in Alcohol; Solution of Sulphate Silver; Solution of Succinate Soda; Polished Plates of Copper, Iron, and Zinc; Sulphate of Iron; Strontia Water.

## FLUXES.

Vitrified Borax; Vitrified Phosphoric Acid; Dried Phosphate Soda; Dried Carbonate Soda; White Flux; Black Flux; Crude Flux; Powdered Green Glass.

## SALTS, SALINE COMPOUNDS, &amp;c.

Carbonate Ammonia, pure and common; Carbonate Barytes native; Carbonate Potash, pure and common; Carbonate Soda, pure and common; Carbonate Strontia, native; Muriate Ammonia; Muriate Lime; Muriate Strontia; Nitrate Ammonia; Nitrate Barytes; Nitrate Copper; Nitrate Lead; Nitrate Potash; Nitrate Mercury; Nitrate Strontia; Oxymuriate Potash; Sulphate Iron; Sulphate Potash; Sulphate Magnesia; Subcarbonate Magnesia.

## OXIDS.

Oxid of Manganese; Red Oxid of Lead; Red Oxid of Mercury; Black and Red Oxid of Iron; Brown Oxid of Copper; White Oxid of Tin.

## SULPHURETS.

Sulphuret Iron; Sulphuret Ammonia; Sulphuret Lime; Sulphuret Potash.

## MISCELLANEOUS ARTICLES.

White Marble; Phosphorus; Sulphuric Ether; Sulphur; Naptha; Oil of Turpentine; boiled Lint-seed Oil; Spirit Varnish; Paris Plaster; Windsor Loam; Stourbridge Clay; Lint-seed Meal; Slips of Bladder; common Lute, for closing Glass Vessels, in preparing all common distilled Liquors; Lute for confining Acid and corrosive Vapours; Fire Lute to join the Covers of Crucibles, so as to keep them air-tight, at a strong heat; Fire Lutes for coating glass and earthenware retorts; Cement for stopping cracks in iron vessels intended to bear a red heat; Resinous cement for fixing tubes, &c. into glass vessels, to be air and water tight; varnish for closely fitting bladders and bags to stop-cocks, and for rendering the joinings of small glass apparatus air-tight; Corks; Bladders;ather; Packthread; Tow; a Rack for draining vials; Filtering Paper; and an abundant supply of distilled Water, and proper selection of Fuel.

\* \* \* In every well furnished Laboratory there should also be ready at hand, specimens of the most important Metals, Salts, Oxids, and other substances not enumerated in this List. They may serve as articles of reference for private study, and other occasional purposes: and are worth preserving even as a matter of curiosity.

## II. CHEMICAL APPARATUS.

*The following are the most essential Chemical Instruments and Utensils, requisite for carrying on a general Course of Chemical Experiments.*

One universal furnace, with sand-bath, muffle, and various kinds of crucible and fire tongs—one or two table lamp furnaces—one flat chemical lamp, and one spirit lamp—a blowpipe, with platina jets, lamp, platina spoon, forceps, and foil—a chemical thermometer—a pneumatic table, with an assortment of bell-glasses, cylindrical receivers, and deflagerating jars—one or two detonating tubes—a bell-glass mounted with stop-cocks, bladders, &c.—an assortment of glass retorts with long necks for procuring gases—one or two cudiometers—a series of graduated cylindrical jars, divided into cubic inches and decimal parts—various sized gas bottles, plain and tubulated—two cast-iron, and one wrought-iron retort with conducting tubes—three or four large bladders, with stop-cocks—one or two air-hoblers—an apparatus for impregnating fluids with gases—a pneumatic mercurial trough, and a sufficient quantity of mercury—one or two nests of cylindrical air-jars adapted for the mercurial trough; plain and graduated—an assortment of glass and earthenware retorts, plain and tubulated, with corresponding glass receivers, also tubulated, plain, and quilled—one or two balloon receivers—a small copper still and refrigeratory—one large and one small glass alembic—a ditto of pure silver, with glass capital—an assortment of earthenware and black lead crucibles round, triangular, and skittle-shaped, with corresponding stands and covers for ditto—a specific gravity bottle—a steam bath, for drying precipitates—one pair of delicate scales, and corresponding weights—two pairs of common hand-scales, and piles of weights for ditto—a galvanic battery with apparatus, for the decomposition of water, and contrivance for obtaining the elements of water in a separate state, &c.—an assortment of glass, porcelain, earthen, and stone ware funnels, plain and ribbed, and three or four glass funnels, with long necks, for charging retorts—glass jars, in sizes, plain and with lips, for decanting or precipitating fluid, and for stirring mixtures—iron standards, with sliding rings for supporting retorts, flasks, basons, and other vessels—a filtering stand, and two or three filtering frames—a series of test tubes and stand—earthenware basons, with spouts, in sizes—an assortment of flasks, assay jars, matrasses and bolt-heads—two or three hand-mortars of porcelain biscuit—one or two iron mortars, in sizes—a series of graduated glass measures, from 2 oz. to 1 pint capacity—Florence flasks, and stands for ditto—various sized iron boilers and paus—kitchen tea kettles, pots, and sauce-paus, of tinmed iron—stoneware pipkins, adopters of glass and earthenware—steel spatulas—a small silver spatula—a ditto of platina—glass and enamel rods, for stirring acid and corrosive mixtures—capillary tubes—metal and glass syphons—a vice—a steel anvil—hammers—flat, round, triangular, and rat-tailed files—ingots, pincers, sheers, scissars, and nippers—iron ladles—glass, silver, and earthenware spoons—sockets and joints, for connecting stop-cocks, &c.—tubes of safety, and bidrostatic funnels—circular pieces of metal, and plates of glass, for covering deflagerating jars, &c.—copper deflagerating ladles—a writing diamond—a mask, to defend the eye against accidents in chemical operations—decanters and finger glasses with lips, such as are used at table—wine, ale, and beer glasses—earthenware basons, tea-cups, and saucers—wide and narrow mouthed vials and bottles of all sizes, plain and ground stoppered—one or two small carboys protected by a basket of wicker-work—stoneware and glass jars, with ti-

ers—earthenware plates—hair, lawn, silk, and wire sieves—flannel, men, and cotton strainers—tiles, slates, stone, and marble slabs—earthenware tubes—gun-barrels—gold, silver, platina, copper, and iron—charcoal paste, for lining crucible.

For carrying on more extensive and specific Researches, the following articles should be ready at hand:

1. barometer—an electrical machine—a double-barrelled table air-  
ump—a hidrostatic balance, or Nicholson's hidrometer—a burning lens  
gazometer—a portable forge and blowpipe table, with double bellows  
freezing apparatus—Wollaston's reflective goniometer—a mineralo-  
d electrometer, a magnetic needle, and deep magnifier—flasks and  
vessels, for weighing gases—Lavoisier's calorimeter—Leslie's differential  
thermometer—metal reflectors—an agate and steel mortar—a blast  
furnace—an apparatus for decomposing the alkalies—a compound distil-  
lary apparatus—a very delicate balance and corresponding weights.

## CHEMICAL PREPARATIONS

### EMPLOYED IN MEDICAL PHARMACY;

*prepared according to the latest edition of the London Pharmacopœia.*

acidum acetieum; acidum aceticum aromaticum; acidum citricum;  
ammonium nitrosum; acidum tartari; ether vitriolicum; liquor ammoniae;  
ossa acetas; potassa carbonas; potassa fessa; soda carbonas; oxidum  
sauonii; antimonium tartaratuin; pulvis antimonialis; argenti  
ras; ferrum ammoniatum; ferri carbonas; hydragyri oxidum ru-  
bin; zincum oxidum.

## CHEMICAL PREPARATIONS

### USED IN THE ARTS AND MANUFACTURES.

aqua fortis simplex; aqua fortis duplex; spiritus nitri fortius; acidum  
osum; acidum nitricum; acidum muriaticum; oxi-muria calcis.

enamel colours; Turkey otto of roses; Tonquin musk: ultra-  
fine permanent white, carmine; Chinese gold; madder lake; liquid  
wax for painting on velvet; and many other articles employed  
in arts and manufactures.

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"We think this work, as an elementary treatise, highly valuable. It is clear, explicit, and comprehensive. The different properties of bodies are detailed with perspicuity, and supported by easy apposite experiments. The particular descriptions are preceded by a clear account of the nature of chemical action; and the facts that demonstrate the attraction and repulsion of bodies. The general laws of corpuscular attraction with the nature of chemical affinity are explained with peculiar simplicity and precision; and the latter is illustrated by easy experiments, &c."

*Critical Review, v. xxxix, p. 380.*

"This Work, which is dedicated by permission to the Managers of the Royal Institution, and patronized by a very respectable list of subscribers, is drawn up for the use of such as are unacquainted with Chemical Science, and will doubtless prove acceptable to the numerous cultivators of the Science of Chemistry.—*Nicholson's Journal,*

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*European Mag. V. xiv. No. 262, p. 55.*

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*Philosoph. Mag. v. xvii. p. 364.*





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